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THE LAND AND WATER RESOURCES OF THE SPRING CREEK BASIN: SOME PROBLEMS OF SETTLEMENT ON THE AGRICULTURAL FRONTIER IN ALBERTA, CANADA.

by

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A THESIS

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FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled The Land and Water Resources of the Spring Creek Basin : Some Problems of Settlement on the Agricultural Frontier in Alberta, Canada, submitted by Ian MacIver in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The Spring Creek basin is a small watershed to the south of the present pioneer fringe in the Peace River area. It is likely to be opened up for homesteading in the next few years and it has been chosen by the Water Resources Branch of the Alberta Department of Agriculture as an International Hydrologic Decade study area. The main aspects to be studied will be changes in stream regime patterns and erosion and sedimentation characteristics caused by the change in vegetative cover.

This thesis is a description and inventory of the land and water resources before any settlement has taken place and is an evaluation of these resources for future use. Material from other sources has been combined with original research to bring together information concerning climate, surficial deposits, soils, slopes, vegetative cover and drainage characteristics. Water balance patterns have also been evaluated but using empirical procedures since few actual measurements of the parameters involved are available for the Peace River area.

It must be emphasised that this study constitutes part of the groundwork for a project which will last for ten years or more. It is based on limited data which will be supplemented in the future but an attempt is made to provide some guidelines for management and further research. In addition to an inventory of the resources the results of farmers' experiences on similar soils elsewhere are analyzed. From these data land-use practices that will be necessary if problems of erosion, flooding, sedimentation, drainage, water deficits, and temperature limitations are to be kept to a minimum have been proposed. The land-use subdivision of the basin is an attempt to minimize the consequences of some problems that may arise. The subdivision and the other recommendations made offer one method of managing the resources on a long-term basis for the benefit of those who will live in the area and for any potential downstream uses which may some day depend on a relatively evenly distributed streamflow free from any increase in sediment load.

ACKNOWLEDGEMENTS

In preparing this study I have received valuable assistance, both financial and otherwise, from Mr. F. L. Grindley, Mr. R. K. Deeprose, Mr. B. Blocksidge and other members of the staff of the Water Resources Branch, Alberta Department of Agriculture, Edmonton. The District Agriculturists and the farmers who replied to the questionnaires provided a wealth of material without which the study would have been impossible. Acknowledgement is made for permission received from Mr. A. G. Underhill of the Water Resources Branch office in Calgary to reproduce Map 7, and from the Alberta Soil Survey to reproduce photograph 6 and the table in Appendix III. Mr. H. W. Glidden and Mr. F. Graves of Spirit River, Mr. N. G. Miller of Grande Prairie, and Mr. J. J. Turcotte of Guy kindly allowed their questionnaire replies to be included as Appendices VIII and IX. Thanks are also due to the Amerada Petroleum Corporation and various members of the staff of the Alberta Department of Lands and Forests, the Department of Municipal Affairs, and of the Prairie Farm Rehabilitation Administration of the Federal Government. In particular I would like to thank my supervisor Dr. A. H. Laycock for his constructive criticism of the thesis at all stages. Mr. W. E. Bowser, Senior Pedologist, Research Branch, Canada Department of Agriculture, Professors J. I. Romanowski and R. W. Longley of the Department of Geography, University of Alberta, and Dr. L. A. Bayrock of the Alberta Research Council also deserve mention for criticizing portions of the manuscript. My wife, Anne, has been of considerable assistance in colouring the maps and in the processing of the questionnaire data. Finally, I wish to thank Mrs. Rhoda Warke for her competent typing of the thesis, and Mr. Jack Chesterman for reproducing the diagrams and photographs.

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INTRODUCTION

Many areas in Alberta have been indiscriminately settled in the past with little or no attention paid to climatic and soil conditions. One unfortunate consequence has been the abandonment of land, especially in the southeast, but most of the Reconnaissance Soil Survey reports show some evidence of this for other parts of the province including the Peace River region. Another result is that a large number of marginally economic farms now exist which provide a low standard of living for their occupants, but these units are fewer in relation to their previous numbers since many have been absorbed by more ambitious neighbouring farmers to create larger enterprises.

In 1940, with the passing of the Provincial Lands Act, and again in 1949 through the Public Lands Act, moves were made to control future land occupation more effectively, and large areas were closed to settlement with the establishment of the "Green Zone." Nearly all of the desirable land outside this prohibited zone has now been settled and occasionally small adjustments are made in the Green Zone boundary to make some of the more favoured areas within it available for homesteading.

The Green Zone, however, was established partly to protect the valuable forest resource particularly in the west, and partly to control settlement upon land which had not already been occupied either because of its remoteness or because, for various reasons, it would be unlikely to provide an economic return for the labour and capital put into it. When these new areas are therefore opened up for settlement some modifications in farming methods may be necessary, the average size of farm may have to be increased, and some added risks of crop or soil damage may have to be faced.

The Water Resources Branch of the Alberta Department of Agriculture, as their contribution to research during the International Hydrologic Decade, decided to make an intensive study of one of these areas which would probably be made available for homesteading sometime within the next ten years. In the study an attempt would be made to evaluate "the effect of agricultural development on the run-off and erosion characteristics of land presently under forest cover."[1] Detailed maps of soils, slopes and vegetative cover would be compiled while the land was still in its virgin state. Hydrological and climatological data would be collected during the forested period, the years of transition, and also after complete agricultural development. The proponents of the proposal recognized as inevitable the fact that pressure on land would necessitate the opening up of land of second rate agricultural quality and also that more information would be desirable in order to make effective recommendations for land and water conservation practices in the Peace River region. Knowledge obtained from this research project, concerning the changes in the hydrologic cycle produced by man's alteration of the environment, should be invaluable when other similar areas in the same part of the province are settled afterwards.

Spring Creek basin, according to the Lands Section of the Alberta Department of Lands and Forests, was the most readily accessible of the areas likely for development in the foreseeable future and its manageable size as a research watershed assured its final selection. During 1965 preliminary investigations of soils and slopes were conducted and roads were improved to facilitate access to all stream gauges and meteorological observation posts at all times of the year. Detailed collection of data will

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[1] R. K. Deeprose, Head of Hydrology Division of Water Resources Branch. Unpublished project proposal to the Canadian National Committee for the International Hydrologic Decade.

begin in 1966 but a considerable amount of material was amassed by the author of this report while in the employment of the Water Resources Branch from May to September of 1965. This thesis, which has arisen from field work conducted in the basin and from other more indirect sources compiled later, is an attempt to forecast difficulties which may arise in the development of the basin and also to suggest methods by which these difficulties may be to some extent overcome. It is a problem analysis study, first describing the resources of the basin as they exist at the moment, then analyzing the problems likely to result from various uses, and finally a scheme of subdivision is drawn up which allots the land to the use to which it seems best suited.

The essence of geography to the author is the study of man's population distribution and the factors, historical, economic, and environmental, which affect it.[2] In a virgin area such as the Spring Creek basin historical influences are minimal and economic factors are closely tied to environmental patterns. The environment as a whole is a rather unfavourable one for agricultural activity since conditions seem to indicate that management for quick cash returns would soon cause rapid soil deterioration and active soil erosion. The area however will be settled, so a compromise must be struck between the conservation through time of the resources for man's use and the necessity to obtain a sufficiently large annual surplus to enable each member of the future farming community to enjoy an acceptable standard of living.

---

[2]Other geographers, of course, may vary in their concept of the discipline's major theme, some placing the emphasis on man and others on his environment but the most common stress is on the interrelationships between the two.

CHAPTER ONE

SPRING CREEK BASIN: THE SETTING

The main resources to be developed either agriculturally or otherwise, i.e., the land and water resources, are treated in as detailed a manner as is possible with the presently available information and separate chapters are therefore devoted to these topics. Other elements are also necessary for a thorough description of the basin and many of these can greatly influence future use either on their own or through their effect on the water and land resources. These other factors are dealt with in this chapter since they form a descriptive introduction to the area and they give information which helps to explain the resource patterns later treated in a fuller fashion. These elements include the location of the basin, its areal extent and its physiography, its present road network and accessibility, its geology and surficial deposits, its climate which has been derived from a study of nearby stations, and the present condition of the land.

(a) Location

Spring Creek is a small stream, intermittent in its upper reaches, which flows into the Simonette from the east about 60 miles above the junction of the latter with the Smoky River (See Map 1). It is located in Townships 68 and 69, Ranges 24, 25 and 26, west of the 5th Meridian. This is slightly to the south of the present pioneer fringe in the Peace River country and only a few miles inside the Green Zone boundary. The basin on its eastern margin forms part of the major divide between the Simonette and Little Smoky rivers.

The point where the present road reaches Spring Creek is 29

MAP 1. SPRING CREEK BASIN — LOCATION MAP



Green Zone

Sturgeon Lake Indian Reserve

Area Covered on Spring Creek Basin Maps

Main Roads

Northern Alberta Railway

Provincial Boundary

10 5 0 10 20 30 40
Miles

Base Map — Alberta Official Road Map

miles from Valleyview and 64 miles from Grande Prairie, the two nearest major shopping and service centres.

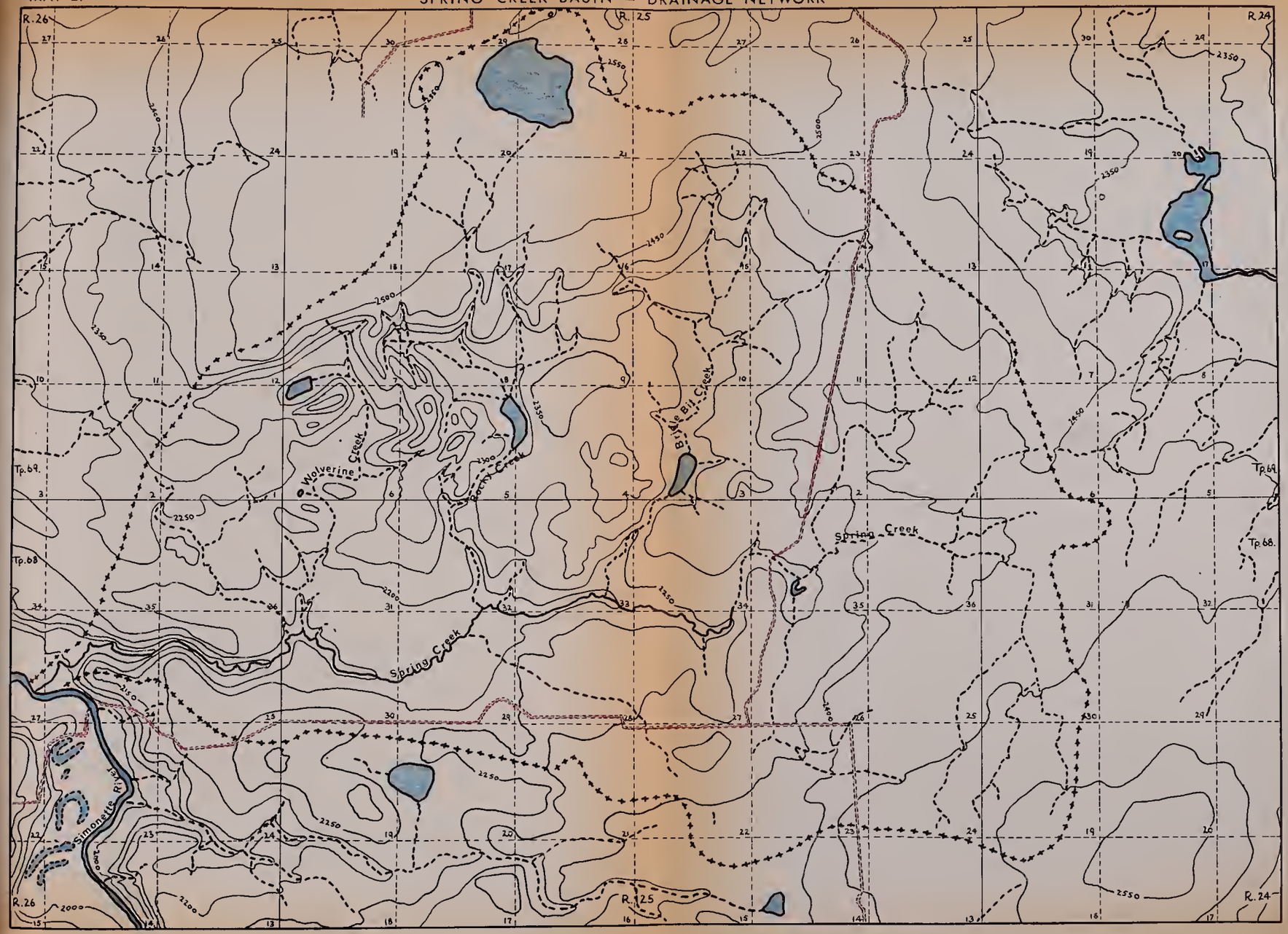
(b) Size and Physiography

The basin is approximately 43 square miles in extent (See Map 2). Only a rough estimate can be arrived at from the published 1:50,000 topographical map sheets and sometimes even from air photographs. A twenty foot contour interval map of the basin, however, is now complete and this enables a reasonably accurate assessment of its area to be made. This size is significantly larger than most other Simonette tributary basins in the neighbourhood but is still not great since the approximately parallel northerly oriented courses of the main streams have foreshortened tributaries flowing at right angles. On the other hand, some basins such as those of Cornwall Creek to the north or Ante Creek to the south, which have northerly trending streams, generally have much larger areas.

Most of the streams that flow into Spring Creek are intermittent except in their lower reaches but the degree of permanency that they exhibit in surface flow has yet to be established. Measurement over a period of years by the Water Resources Branch should clarify this point. Some of the channels joining the more outlying sloughs and depressions to the main stream are ephemeral rather than intermittent and only run in the wetter years when water levels rise high enough for overflow to occur. It therefore takes above average precipitation, or snow-melt conditions, to increase the basin to its maximum extent and to connect all the minor temporary interior drainage basins to the main network. Even the large lake in sections 20 and 21 of Tp. 69 R. 25 showed no signs of surface flow from its outlet when examined in June 1965.

MAP 2.

SPRING CREEK BASIN — DRAINAGE NETWORK



KEY

- LAKES
- PERMANENT STREAMS
- INTERMITTENT STREAMS
- BOUNDARY OF DRAINAGE BASIN
- DRY-WEATHER ROAD
- CONTOUR INTERVAL IS 50 FEET

Source — Topographical Sheet 83 K/13. D.M.T.S. 1960.

The proportion of the basin area that will provide streamflow in any one year depends on the topography as well as on the precipitation. This basin has more land in slope than is usual in the Peace River country so the area normally contributing to runoff is proportionately higher and probably amounts to more than half of the basin in most years.

Spring Creek basin is more steeply sloping than most settled areas nearby because of its proximity to a major stream. However, it is still an area of fairly gentle slopes with only a small proportion of very steeply sloping land but also very little land that is completely flat. Some facets of the elevation and slope characteristics of the basin are illustrated in figures 1 to 3.[1] The altitude varies from just under 2000 feet to just over 2550 feet with over half of the area between 2250 and 2400 feet but a greater range of height is present in the land below this belt than is present in the land above it. This would seem to suggest that the interfluves are rather flat and that there is some degree of incision near the river itself. Most of the slopes in excess of ten percent are in this incised portion. The median slope is just over two percent which on some Peace River soils is steep enough to make water erosion a problem under certain conditions.[2] This aspect will be dealt with later.

The Simonette River flows at an elevation of 1970 feet and its

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[1] The methods used in constructing these diagrams are described in Appendix I.

[2] The mean value was not used since this is excessively affected by the few areas with slopes as high as 24 percent.

SPRING CREEK

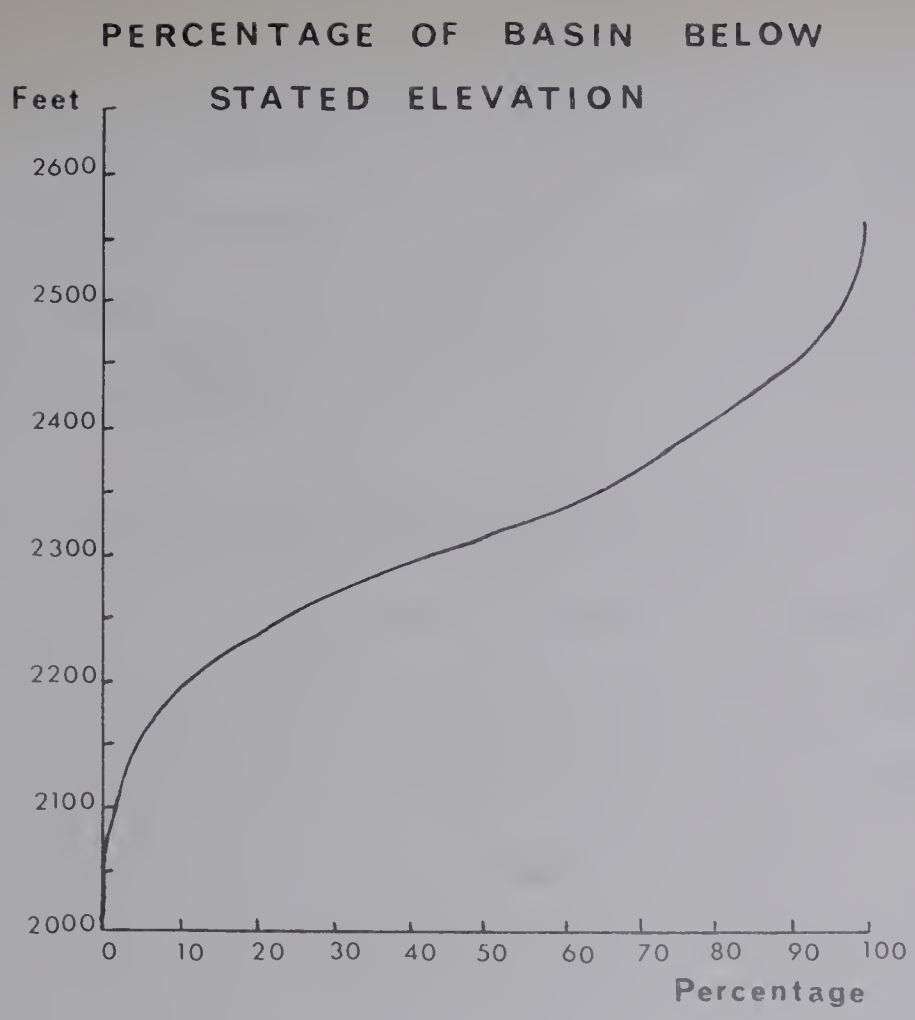


FIG. 1

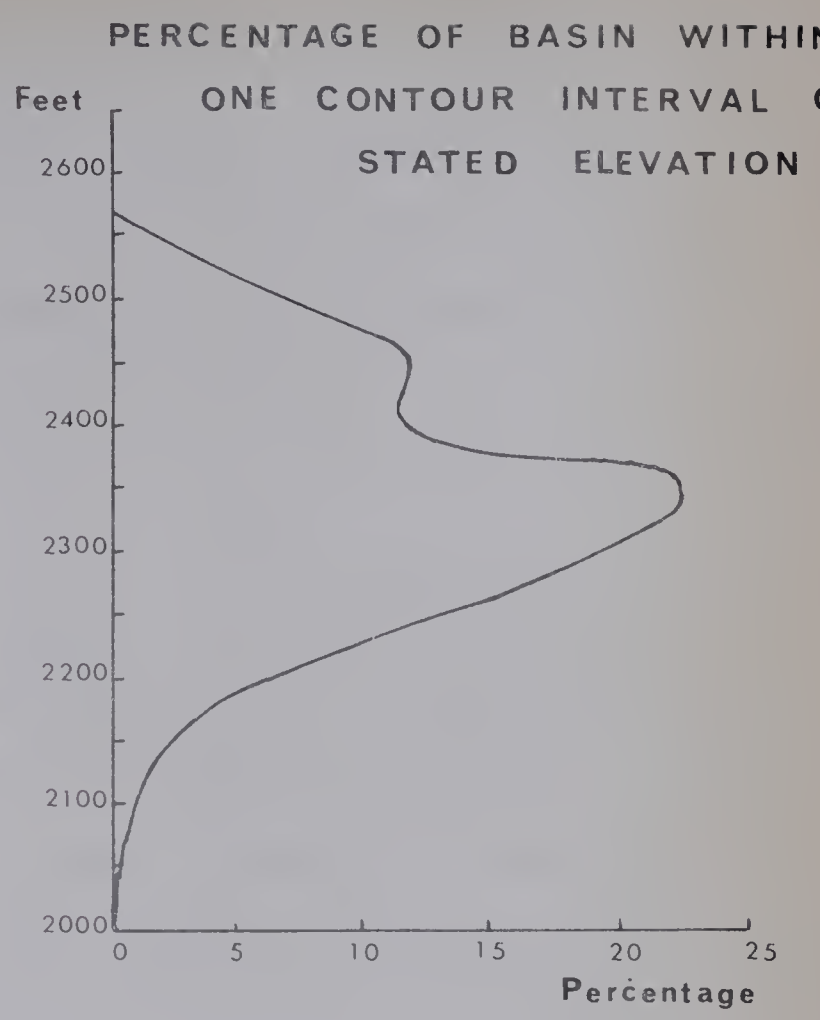
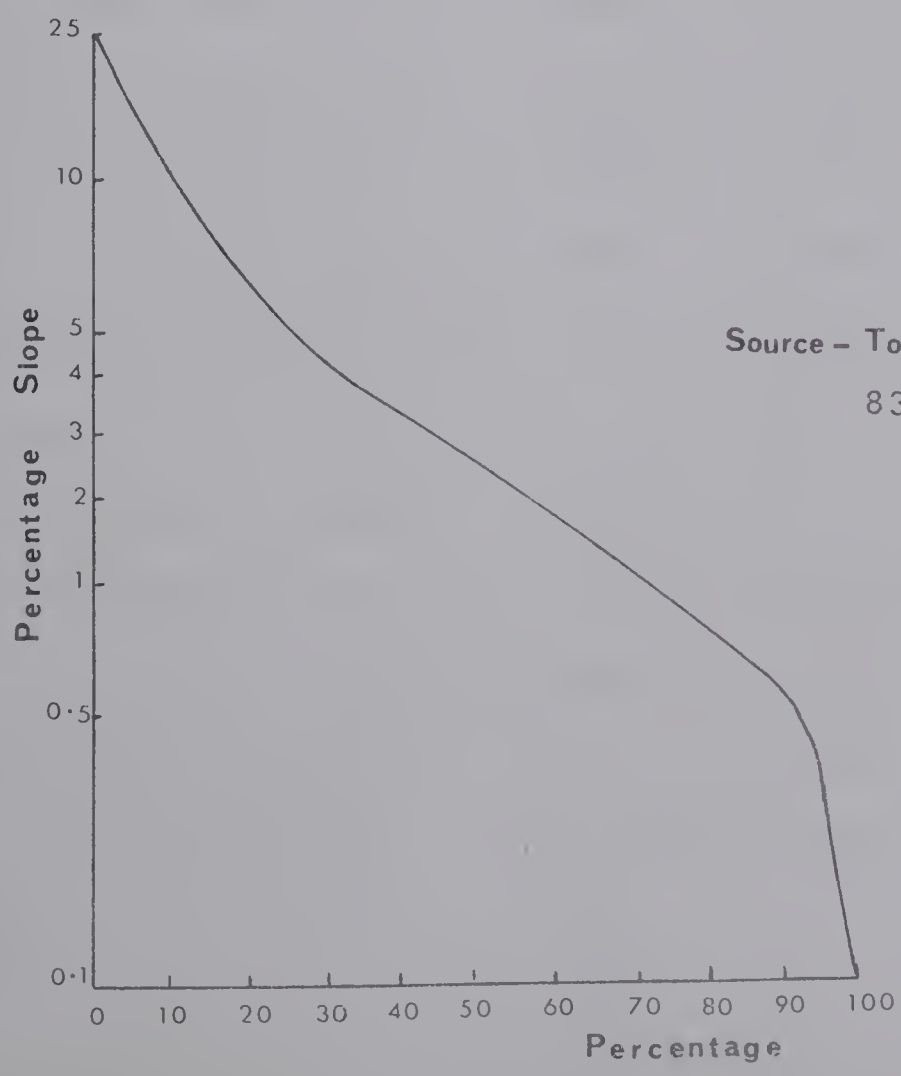


FIG. 2



Source – Topographical Map Sheets 83K/13 E and W.

FIG. 3

tributaries are incising to this base level. In their lower courses they have therefore cut deep steep-sided channels into the undulating surface of youth which exists at the higher level. These flatter interfluves are the areas of confused and generally intermittent drainage discussed previously.

(c) Transport and Accessibility

Only one road passes through the basin at present (see Map 2). It was built in 1953 by the Amerada Petroleum Company, maintained afterwards by Northern Canadian Forest Industries and extensively reconstructed and repaired by the Water Resources Branch in 1965. It can now be used in all types of weather and a side road is being constructed just north of the creek and running west to meet it in Section 25 Tp 68 R. 26, more than a mile east of the junction of the creek with the Simonette.

These roads represent the minimum facilities necessary to provide the forestry company with access to any valuable timber near the Simonette River, and for Water Resources to reach its hydrometric gauges. When settlement occurs in the future the road system will need to be greatly increased in density. In some of the lower parts of the basin the degree of slope may make it uneconomic to do this and still follow the orthodox rectangular grid pattern.

The quality and density of the planned road network will be of considerable importance in influencing people's decision to settle in the area. Its distance from various services may affect agriculture as well as food costs, transportation costs, supplementary employment

opportunities, and facilities for education. Valleyview is 25 road miles from the northern edge of the basin and 36 miles away from the mouth of the creek. Grande Prairie is 60 miles away from the basin's edge but shopping, marketing and servicing facilities are much superior there. Grande Prairie is also the nearest rail centre which means that it can be rather expensive to ship grain this distance to the elevators, but the quality of the road between the farm and the main highway at Sturgeon Heights is more critical if large loads are to travel over it. Distance from railhead combined with local road conditions can therefore influence any balance between a grain and a livestock emphasis. In this latter case also distance can be an adverse factor affecting final profits.

The present programme of school amalgamation and centralization means that children from more outlying areas have to travel further to school than was previously the case. School facilities come high on the list of considerations when people are looking for an area to homestead. This is especially true for young couples who may have grown up in the Peace River area themselves and whose education may have suffered either through distance to school or through poor road connections at certain times of the year. Children will have to travel a distance of 18 miles from the northern edge of the basin to Crooked Creek (Ridge Valley School) for all grades from three to twelve, and 24 miles to Edson Trail School for grades one and two. A possible alternative in the future is for all children to travel the 25 miles to Valleyview where the school offers grades one to twelve with a wider choice of subjects for the older student than Ridge Valley can give.

Transportation services between the basin and Grande Prairie

and Edmonton are relatively good. Edmonton can be reached in five hours by car, and three buses per day run from Edmonton, via Valleyview and Grande Prairie, to Fort St. John and vice versa. At Valleyview, where two other buses turn north towards the MacKenzie Highway and the North West Territories, the number of daily connections with Edmonton is increased to five.

(d) Geology and Surficial Deposits

No actual outcrops of bedrock have so far been discovered within the basin. A seismic shot-hole map was obtained from the Amerada Petroleum Company which showed 184 sample holes drilled within the basin. Four small areas have bedrock near enough to the surface to be recorded by the 40 foot logs. Two of these areas, one being a small part of the extreme southeastern corner of the basin and the other in the northeast where the main road leaves the basin, have an average depth to bedrock of 25 feet. The other two areas, near the headwaters of Wolverine Creek and also in Section 9 Tp. 69, R. 25 have bedrock at a depth of 20 feet. The rock tends to be brown or blue shale with some sandstone and thin coal seams. The shot-holes reaching bedrock, however, just amount to nineteen or about one tenth of the total number. A few shot-holes are close to the creek, and even in its incised valley as near as two miles from its mouth, but no bedrock was reached here either. Extensive slumping patterns along the valley sides have obscured any areas where outcrops might have been visible.

There is therefore no direct visible evidence available for a discussion of the local bedrock but other sources exist which give some

general indications of its nature. Two deep drillings (marked A and B on the surficial deposits map) have been bored to a depth of over 10,000 feet within the basin by Amerada and these give a complete picture of the strata below 1000 feet, at which depth the Upper Cretaceous Dunvegan group is present. Unfortunately this omission excludes the uppermost and most interesting part of the record. This can, in part, be made up from information contained in Alberta Research Council reports and also in the Geological History of Western Canada.[3] These publications state that immediately above the Dunvegan formation is the Smoky River formation which is mainly a marine shale group and above this again is the Wapiti formation which consists largely of freshwater thickly-bedded sandstones, shaly sandstones and shales. The Wapiti formation is often subdivided into two separate formations and the boundary between the two probably occurs just a few miles to the north of the basin.[4] To the north is the older Belly River formation which consists of grey and green sandstone and shale, with some bentonitic carbonaceous and concretionary shales, conglomerate, and coal. Within the basin, and probably still quite a thin layer above Belly River rocks, are the rocks of the Edmonton formation which is composed of grey bentonitic sandstone and shale, with some grey, greenish and carbonaceous shales, conglomerate, bentonite, and coal.[5]

---

[3]R. L. Rutherford, Research Council of Alberta Report No. 21, 1930. J. A. Allen and R. L. Rutherford, Research Council of Alberta Report No. 30, 1934. Alberta Society of Petroleum Geologists, A Geological History of Western Canada, Calgary, 1965.

[4]Deduced from A Geological History of Western Canada; also the Geological Map of Alberta, Canada Dept. of Mines and Tech. Surveys, Map 1002A, 1951.

[5]Description as shown in the key of the geology map 1002A.

The bedrock is completely covered by surficial deposits but since most of these deposits are of glacial origin the bedrock must be known if their composition is to be understood. These deposits are very important from an agricultural point of view and they have been mapped from the Reconnaissance Soil Survey report,[6] supplemented by ground checks, seismic shot-hole reports, and aerial photographic interpretation.

The classification used on the surficial geology map (see Map 3) depends on that used in the reconnaissance soil survey insofar as the till and lacustro-till categories are concerned. The till, or unstratified glacial drift, tends to occupy the higher areas and exhibits the common swell and swale type of topography with sloughs which show through the forest covering as marshy depressions. On some of the minor topographic highs seismic shot-hole records show the till to be as thin as twenty feet.

The nearest sample of Peace River till quoted in the literature as having undergone mechanical analysis is from the Saddle Hills at a point about 24 miles north-northeast of Grande Prairie and 48 miles from Spring Creek basin.[7] The percentages of sand, silt and clay in the B horizon are 26, 37 and 37 respectively. A considerable degree of variation in till composition is present farther north in the Peace River area but since this sample was taken from a Braeburn soil area

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[6] W. Odynsky, A. Wynnyk, and J. D. Newton. Reconnaissance Soil Survey of the Grande Prairie and Sturgeon Lake Sheets. Research Council of Alberta, Report No. 74, 1956.

[7] C. P. Gravenor and L. A. Bayrock. "Glacial Deposits of

(the most common soil series developed on till in the basin) it is probably quite representative of Spring Creek basin till.

In the southeast the till shows flutings trending from north-northeast to south-southwest and this is taken to mark the direction of ice movement during its last phase. These flutings are even more frequent about ten miles north of the map area; i.e. just south of the Sturgeon Lake Indian Reserve and along Highway 34 between Calais and Valleyview.

The topography of the till in sections 5, 6, 7 and 8 of Tp 69, R. 25 is rather unusual. Concentric ridges facing in an easterly direction are backed by a basin depression occupied by a lake with a 200 foot 25 percent slope immediately behind. A similar feature with rather less variation in height has been noted by Dr. Bayrock near Altario and this he considers may have been formed by a large mudflow.[8] Other explanations such as stream dissection, ice-push moraine, and moraine between two lakes of ice have been considered for the Spring Creek basin feature but none seem to fit all the topographical details so well as does the mudflow theory.

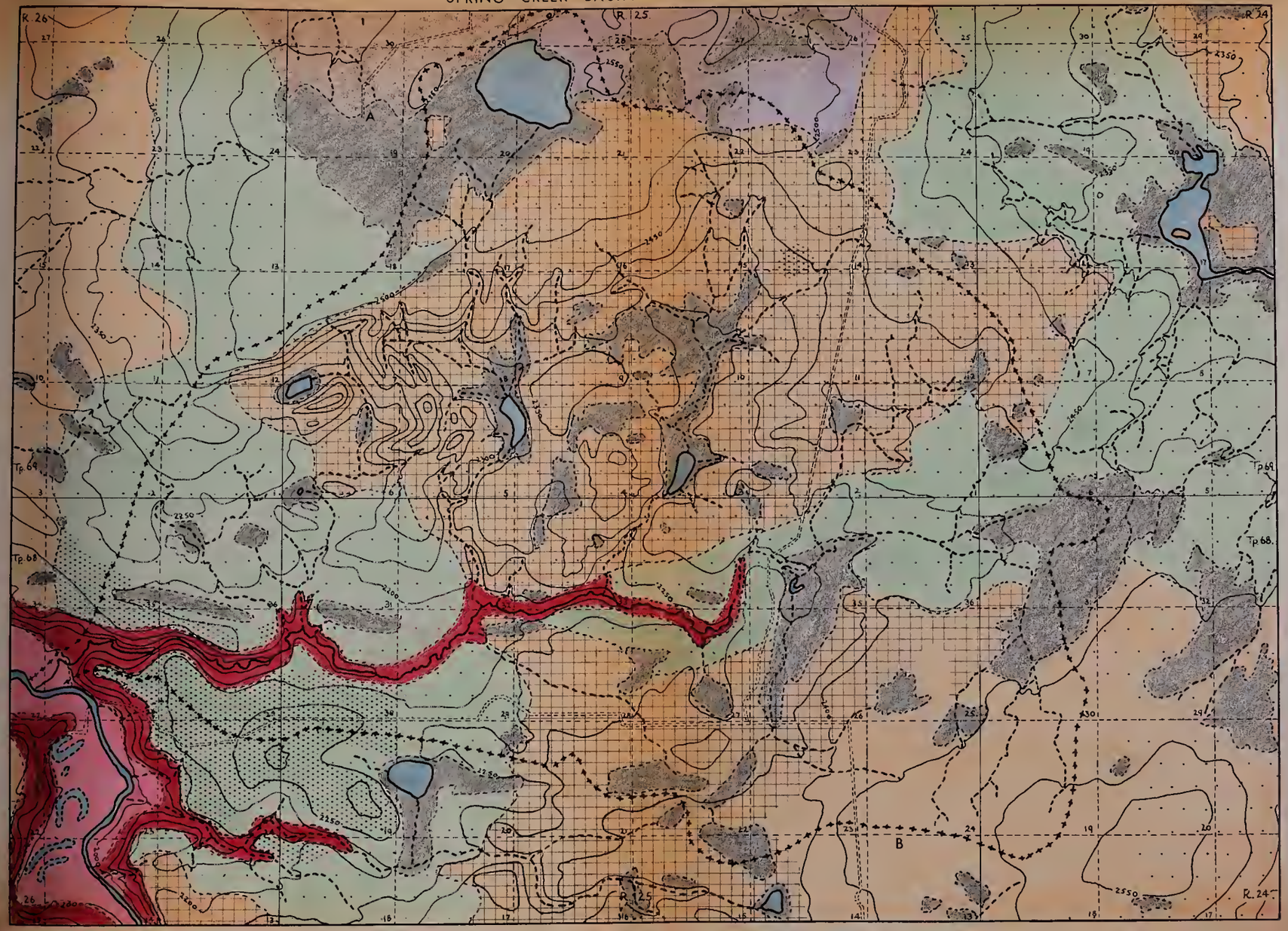
Much of the till within the basin is covered by layers of lacustro-till and alluvial deposits. These layers are generally quite thin, more so in the case of the alluvial material which under these conditions rarely exceeds thirty inches in thickness.

Alberta," p. 45 in Soils in Canada. Edited by R. F. Legget. University of Toronto Press, 1961.
W. Odynsky, A. Wynnyk, and J. D. Newton, 1956, op. cit., p. 104.

[8]Interview with Dr. L. A. Bayrock, Earth Sciences Division, Alberta Research Council, July 1965.

MAP 3.

SPRING CREEK BASIN – SURFICIAL DEPOSITS



KEY

- TILL
- LACUSTRO-TILL
- KAME MORAINE
- PITTED OUTWASH
- ERODED VALLEY SIDES
- RECENT ALLUVIUM
- PREDOMINANTLY MARSH
- Thin patchy cover of lacustro-till on top of glacial till
- Covering of alluvial-eolian material on top of till or lacustro-till
- A very sandy sub-type of the alluvial-eolian classification
- A Deep Drillings

Source – Topographical Sheet 83K/13. D.M.T.S. 1960.

Lacustro-till, as the term is used by the Alberta Soil Survey, consists of a sorted clayey material which may have been laid down in a glacial lake. Bands of sandy, gravelly or even stony till-like material can also be present and it is thought that this may be typical of the marginal portions of the lacustro-till areas.[9]

The definition of the term "lacustro-till" comes within the compass of diamicton which includes poorly sorted terrigenous deposits that consist of sand and/or larger particles in a muddy matrix.[10] One of the means of formation of diamicton was considered to be ice-rafting and it would appear that in the Spring Creek basin this material was laid down at a time when the ice front lay to the northwest and a lake covered the area in question. Icebergs calving from the ice front, probably during the early stages of the lake's history, would tend to be driven away from the ice toward the south or southeast by katabatic wind action and the iceberg would eventually be stranded on some topographic high where slow melting would take place. The deposition of the englacial material would be in water and may also have been subjected to some wave action and sorting. This mechanism could result in till-like material with lacustrine-like layering and was described for this region by Dr. Bayrock.[11] It would work best on a gently sloping area facing the lake and

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[9] W. Odynsky et al. Reconnaissance Soil Survey of the Beaverlodge and Blueberry Mountain Sheets. Research Council of Alberta, Report No. 81. 1961, p. 26.

[10] R. F. Flint, J. E. Sanders, and J. Rodgers. "Symmictite." Bulletin of the Geological Society of America, Vol. 71, p. 508. R. J. Flint, etc. "Diamictite, A Substitute Term for Symmictite." Bull. Geol. Sec. Amer., Vol. 71, p. 1809.

[11] Interview, July 1965.

the large area of lacustro-till in the northwest fits these conditions better than any does anywhere else. In the other parts of the basin lacustro-till is more till-like in topographic expression as well as in composition which would indicate that it is thinner and the underlying till undulations have not been completely masked. For example on the margin of the map in the east-central area (section 4, Tp. 69, R. 24 and section 33, Tp. 68, R. 24) traces of flutings moulded in the till below are still discernible on air photos.

The boundary between regions where lacustro-till is dominant and those where it occupies a lesser areal expanse than till is rather arbitrarily chosen and so does not represent any clear-cut lake level. Some lacustro-till occurs within the till zone to elevations approaching 2500 feet. Future investigations may reveal more detail about this material but enough has been elucidated in this study to assess its value as a soil parent material, which is its most relevant application.

An area of kame moraine or ice-contact fluvially deposited material is mapped on the north-central margin of the map. This can be seen on air photographs to consist of irregularly shaped kames, unevenly distributed, with large areas of muskeg in between.

To the west of the kame moraine is an area of pitted outwash which gets progressively finer in surface texture and less pitted in nature towards its western margin. Most of this area is underlain by coarse gravel which occurs at the surface in the east where it has been worked for road building purposes by Amerada when deep exploratory drilling was done at point A on the surficial deposits map. The steep

eastern face, up to 30 feet high in places, is probably in ice-contact face.

The incision of the Simonette valley has developed to such an extent that the steep-sided edges are classified separately as a zone of erosion by gullying and mass movement. Extensive areas of slumping are evident in this zone. Even the dense forest cover has not always offered sufficient protection. This zone also extends into the tributary valleys since they enter the Simonette at grade.

Extensive recent deposits of alluvium are present in the Simonette valley. Gradations from coarse gravel to clay can be seen in exposures on both sides of the river and several levels of terraces occur although these are less evident in the vicinity of Spring Creek than elsewhere. An interesting feature is the presence of two old oxbow lakes part of the way up the valley side on the western bank of the Simonette.

Another subdivision shown on the map is deposition due to alluvial and eolian action outside the Simonette floodplain. This has been indicated on the map by a dot pattern and it appears as an overlay on many parts of the till and lacustro-till. The alluvium in the minor valleys accumulates under normal geologic processes but is accelerated by periodic burning which every so often exposes loose soil, making severe erosion possible until a vegetative cover re-establishes itself. Some of this alluvial eolian material is of immediately post-glacial origin when unconsolidated and uncovered till and lacustrine sediments were worked on by wind and water. Much of the till and lacustro-till surfaces in the valleys, therefore, have a thin covering of sandy or silty material which usually appears as Codesa in the soils section. It is to be hoped that in some of

these valley locations man does not intensify the erosion problem when clearing and cultivation take place.

Where sandy material is especially deep a denser dot pattern has been used to indicate it and in the area between Spring Creek, the Simonette valley, and the semi-circular curve in the main road there is an area of stabilised sand dunes where as much as twelve feet of sand have been recorded in shot-hole logs. These may be lacustrine shoreline deposits, possibly of Lake Puskwaskau II, during the late Wisconsin stage. This lake is indicated by Henderson to have been longer-lived than most pro-glacial lakes in this area,[8] and it may have persisted for as long as 400 years with a considerable time when the shoreline elevation was around 2200 feet. Lake Puskwaskau sediments, commonly showing dune development, extend from this point to a point a few miles southwest of Grande Prairie, generally around the 2100 foot level but occasionally extending as high as 2200 feet. Since glacial times the dominant westerly winds have produced the characteristic U-shaped dune pattern with the horns pointing into the wind.

Areas of muskeg and other types of marsh have been shown as such on the map. No attempt has been made to differentiate them on the basis of underlying material since this is unlikely to have much bearing on the utilization of these areas.

(e) Climate

The climate or average weather picture of the Peace River country is a product mainly of the interaction of Polar Maritime air

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[8] E. P. Henderson, The Surficial Geology of the Sturgeon Lake Map-Area, Alberta. Geological Survey of Canada, Memoir 303, 1959, pp. 43, 45, and Figure 7.

from the Pacific and Polar Continental air from the northern interior of the country. Tropical air from the Gulf of Mexico rarely penetrates this far northwest but when it does heavy precipitation may result.[9]

Some indication of temperature patterns in the southern part of the Peace River settled area can be obtained from Figures 4 and 5. These have been compiled from the 22 year period of records available for Grande Prairie airport, the nearest meteorological station with a long period of uninterrupted record. The large mean annual range (57°F) is further accentuated by variations in the same month from year to year, variations caused by the differing persistencies of two very different air masses. The variation, as portrayed in Figure 4 by the scatter of readings obtained over a period of years, is particularly great in the winter months when temperature differences between polar maritime air and polar continental air are at a maximum. In summer when these air masses vary more in humidity than in temperature, a much smaller monthly range is experienced. This winter variability is carried over, as would be expected, into the graph of mean annual temperatures (Figure 5). One or two extreme months can depress the annual mean considerably. In the years 1950 and 1951, for example, both of which show low mean annual temperatures, 1950 had the coldest January within the period of record (-22.3°F mean temperature) and 1951 had a cool summer with no month reaching 60°F.

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[9]C. C. Boughner and M. K. Thomas, "The Climate of Canada," Queen's Printer, Ottawa, 1962, p. 15. Reprinted from The Canada Yearbook 1959 and 1960. Dominion Bureau of Statistics, Ottawa.

Although no temperature records for long periods are available from stations nearer to Spring Creek, the short term records that do exist show patterns very similar to the conditions prevailing at Grande Prairie. It seems likely, however, that the mean annual temperature in a fairly level part of the basin (to allow for a more realistic comparison with Grande Prairie) would be about two to four degrees lower since the basin is still forested.[10] This difference would mainly be caused by the shading effect of the trees which would keep the daily maxima near the ground lower during the summer period.[11] With extensive clearing in the future it is to be expected that this difference between the two areas would be lessened.

The degree of relief is not sufficient to cause a great variation in temperature patterns throughout the basin caused by altitude alone. On the other hand local relief variations where relatively minor basins or hollows are present can produce significant temperature inversions because of the tendency of cold air to settle and drain to the lowest level in the neighbourhood. Minimum daily temperatures (especially during the winter) are most affected. Readings taken at Beaverlodge from 1930 to 1942 on a hilltop and in a slough half a mile away and 134 feet lower in elevation were 6.9°F lower in the slough.[12] The practical

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[10] R. K. Linsley, M. A. Kohler, J. H. L. Paulhus. Hydrology for Engineers, McGraw-Hill Inc., 1958, p. 12. This can also be seen in the mean daily temperature maps for the summer months in G. A. MacKay, Climatic Maps of the Prairie Provinces for Agriculture, 1965.

[11] Potential evapotranspiration would not be greatly affected since this takes place more from the top levels of tree growth.

[12] W. D. Albright, J. G. Stoker, "Topography and Minimum

GRANDE PRAIRIE - MEAN MONTHLY TEMPERATURES 1943 - 64

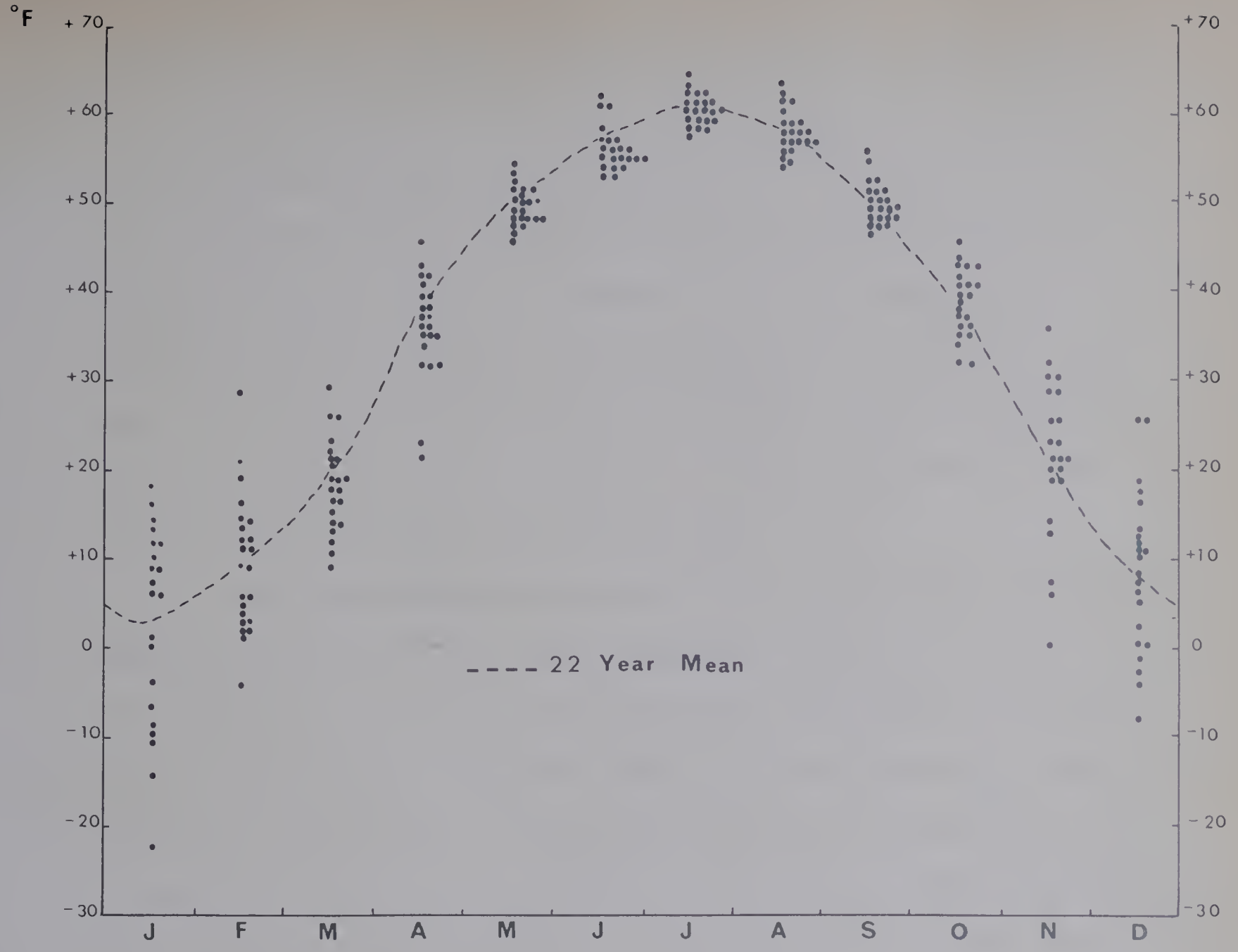


FIG.4

GRANDE PRAIRIE - MEAN ANNUAL TEMPERATURE
1942 - 64

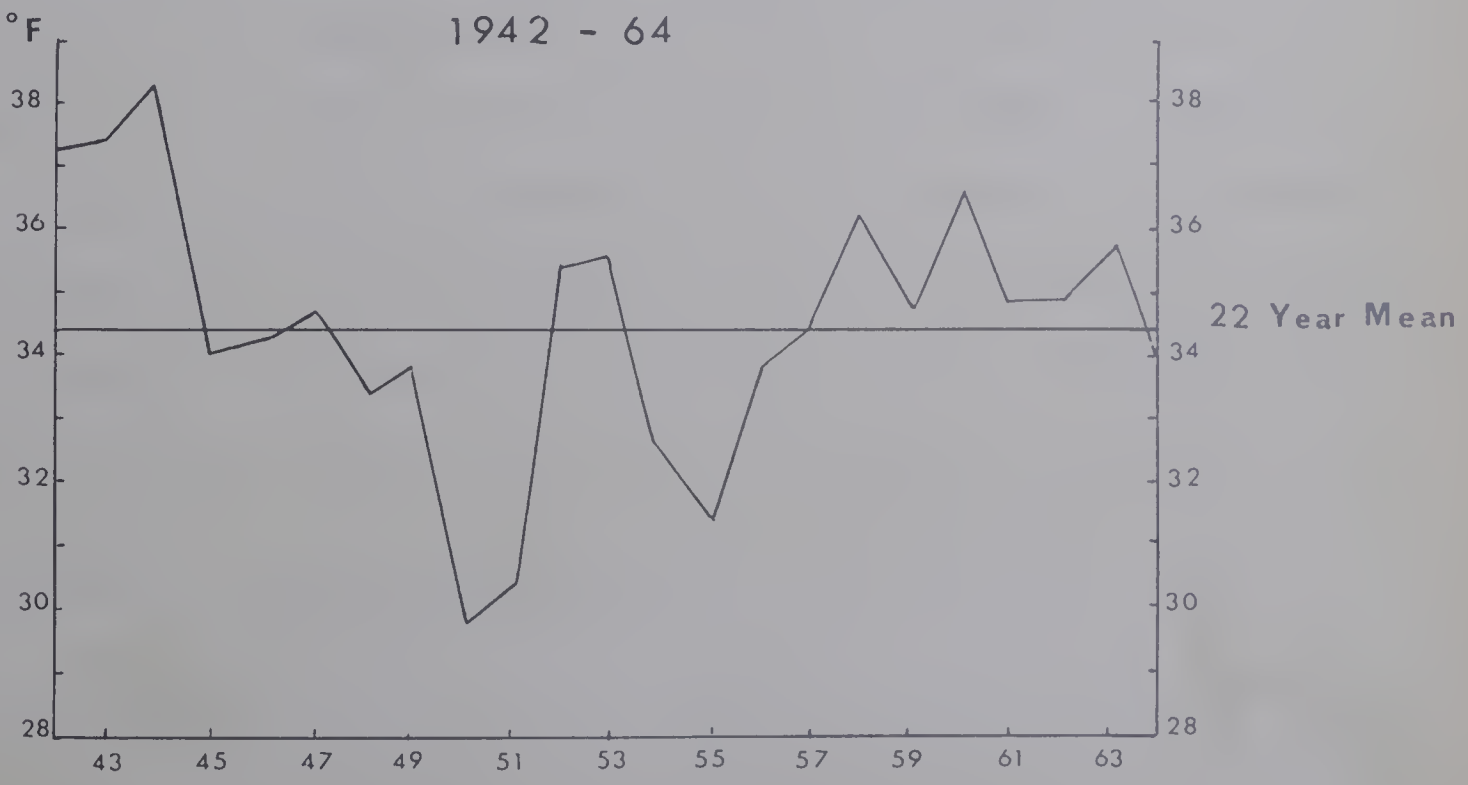


FIG. 5

Compiled from Dept. of Transport Monthly Meteorological Reports 1942-64

importance of this study for agricultural purposes is emphasized by comparing the frost-free season for each locality. On the hilltop the frost-free season ranged from 66 days in 1935 to 129 days in 1940 with the average for an eleven-year period (1932-42) of 106 days. In the slough there was frost every ten days in 1933, the longest frost-free period was 76 days in 1941, and the eleven-year average was only 32 days. Thus the frost-free season on the hilltop was, on the average, more than three times as long as in the slough. In the slough frost occurred in every month of an average year.

The topography of the Spring Creek area includes many minor marshy hollows and a few longer slopes (for example in Sections 10, 11, 14 and 15, Tp. 69, R. 25) which will provide admirable opportunities for the collection of cold air when parts of the basin have been cleared for agriculture. Temperature statistics must therefore be treated with caution and the location of a given set of meteorological instruments should be carefully considered since in the above-mentioned survey it was suggested that in some years the temperature differences probably resulted in a greater ecological difference between the slough and the hilltop than between Beaverlodge and Lethbridge 380 miles farther south and about 500 feet higher in elevation.[13]

Some precipitation patterns for Grande Prairie are indicated in Figures 6 and 7. Precipitation records are also available for Debolt (three stations at various times, including Goodwin), Valleyview, Economy, Simonette, Smoky Tower, Snuff Mountain and Sweathouse. Most

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Temperature," Scientific Agriculture, V. 25, 1944-45, p. 150.

[13] Ibid., p. 154.

of these reports are for the period from May to October and only Sweathouse, Snuff Mountain and Economy have records for more than ten years. Another factor detrimental from the meteorological point of view is that these are forestry lookout posts and are therefore situated on exposed points which are not ideal sites for recording typical precipitation amounts. An interpolated record in every case gives a higher mean annual precipitation than the Grande Prairie total. Snuff Mountain (at 3000 feet and 19 miles south-southeast of Spring Creek) has an estimated precipitation of 23 inches, Economy (at 2600 feet and 17 miles west-southwest of the basin) has 24 inches, and Sweathouse (at 2800 feet and 34 miles to the east) has 26 inches, assuming that 63 per cent falls in the summer six months as is the case for Grande Prairie. These will not be typical of the area in general because of the exposed situation of each and in any case the period from 1953 to the present, for which these stations have records, was wetter than the previous decade. Grande Prairie's annual precipitation for this period was 18.8 inches compared with the 17.8 inch average for the 22-year period.

High Prairie has a longer period of record than Grande Prairie but interruptions, especially in the recording of precipitation, are frequent; for example, records are available for only five months in 1963 and one month in 1964. The 22-year average, however, using Grande Prairie values to fill in the gaps, is again 17.8 inches so it was felt that no purpose would be served in using both sets of records except to show that for open relatively level areas in the southern part of the Peace River country the precipitation totals tend to be quite similar to the values plotted.

Precipitation in this region as in the Prairies as a whole, is usually associated with cyclonic activity. In many mid-latitude parts of the world, this is at a maximum of intensity during the winter half of the year, but here the continental high pressure area covers the basin for most of that period so the majority of storms pass far to the south. In addition the air contains little moisture in winter time. Most of the precipitation falling during this season is received from Polar Maritime air which is forced upward on warm fronts after its occasional penetrations into the area. In summer activity increases and is often combined with latent instability caused by surface heating. These factors, together with the higher moisture content of the air, help to give a marked summer precipitation maximum.[14] This summer maximum for Grande Prairie can be seen in Figure 6, July having slightly more rain than June, to be followed by a decline in the autumn, a very slight recovery in December and January, and a definite yearly minimum in March and April. In winter (November to April) variation from one year to the next can be seen to be much smaller than in summer and this can be partly explained by the fact that most winter precipitation is frontal in origin, little being derived from any other source. In summer, in constrast, instability caused by surface heating is combined with some cyclonic activity, and the occasional excessively high monthly totals are often caused by inroads

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[14]Part of this paragraph was adapted from G. R. Kendall and M. K. Thomas, "Some Characteristics of Precipitation in the Canadian Prairies." Separata de Miscelenea Geofisica, Luanda, 1956, p. 313.

GRANDE PRAIRIE - MONTHLY PRECIPITATION 1943-64

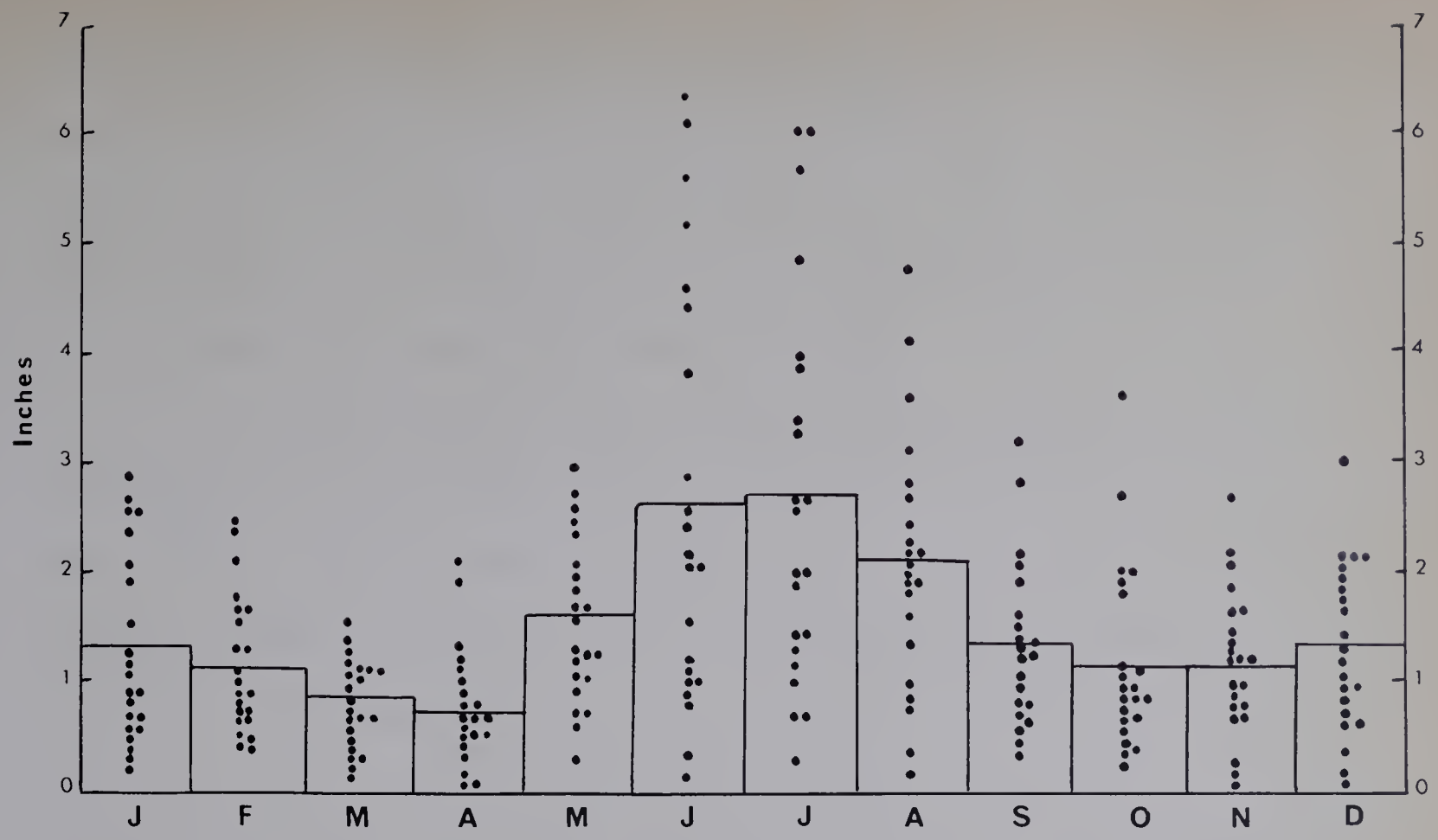
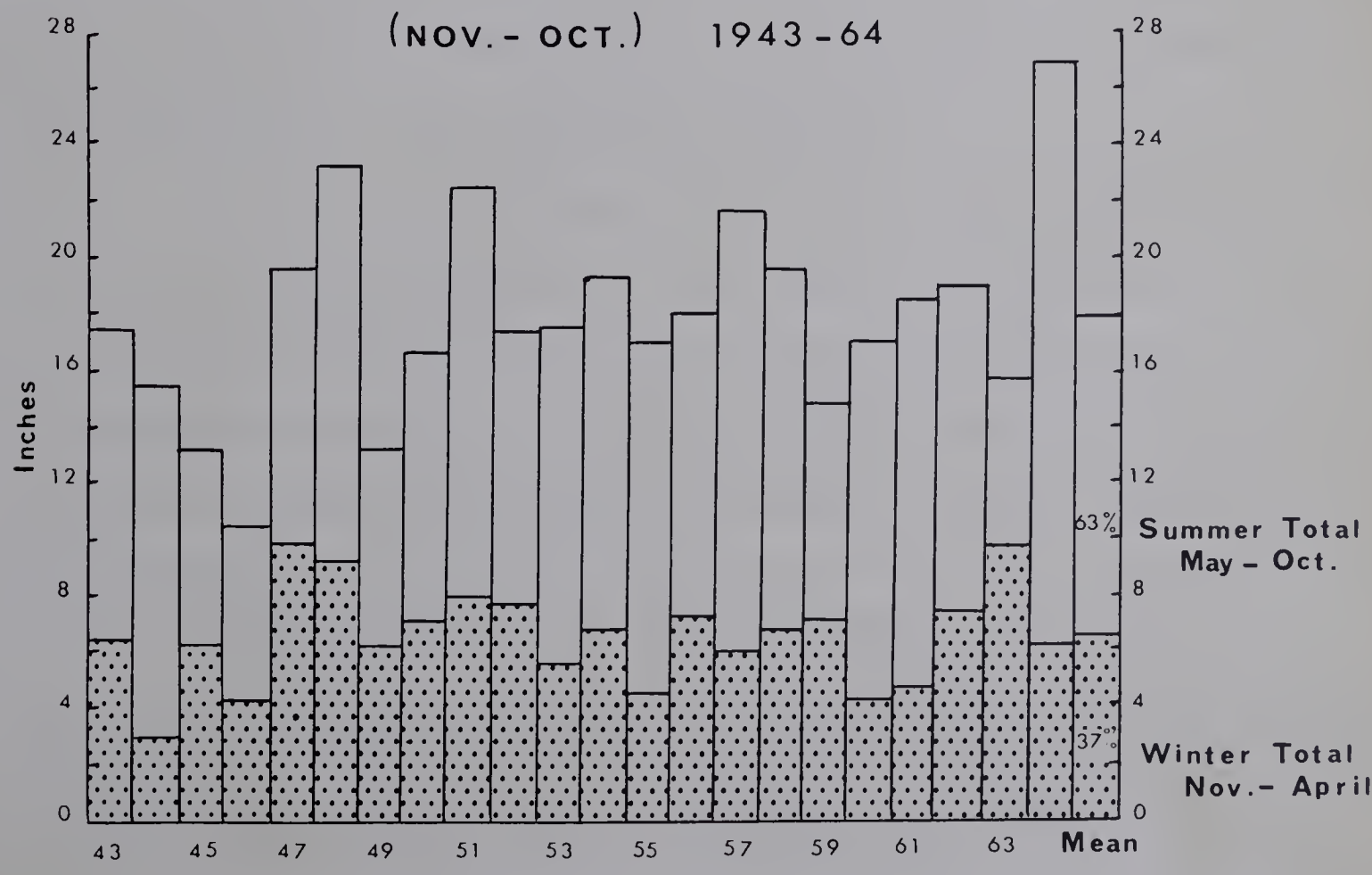


FIG. 6

GRANDE PRAIRIE - HALF-YEARLY PRECIPITATION

(NOV. - OCT.) 1943-64



Compiled from Dept. of Transport Monthly Meteorological Reports 1942-64

FIG. 7

of Tropical Maritime air which gradually loses its capacity to contain great amounts of moisture as it advances northwards and so heavy precipitation can result.[15] This means that more variables causing precipitation are present in summer so a greater degree of scatter can be seen in the individual monthly records.

The annual precipitation pattern in the Spring Creek basin will probably closely resemble the pattern for Grande Prairie but the forestry look-out posts would lead one to suspect that the total is slightly higher. Possibly nineteen inches is a truer estimate.[16] In both cases moisture surpluses are more likely to accrue from winter snowfall rather than from the greater summer rainfall which is mainly used up in evapotranspiration. There is a large total precipitation for 1964 (Figure 4) but not a great surplus as computed from Thornthwaite's procedures since the high summer precipitation meant that no deficit occurred but it added little to the annual surplus. Low summer precipitation, especially if combined with earlier poor recharge, will result in low crop yields--1946 being a good example.

The annual precipitation varies from a low of under 11 inches in 1946 to a high of 27 inches in 1964 (Figure 7). The diagram has been constructed so as to facilitate the separation of precipitation into winter and summer sub-totals. The six months from November to April inclusive were considered as winter while May to October constitute the

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[15] C. C. Bougner and M. K. Thomas, op. cit., p. 15.

[16] This agrees closely with G. A. MacKay, "A Detailed Map of Prairie Average Annual Precipitation," Meteorological Branch circular 3519, Tec. 365, 1961. It is about three inches less than his estimate in Climatic Maps of the Prairie Provinces for Agriculture, Map 14, 1965. This map uses forestry lookout station records.

summer period. April and October both have mean monthly temperatures in the 30's but April is generally colder, has a greater number of years with a mean value below 32°F., and also nearly always has some snow cover for part of the month. For this reason it was included in the winter half-year. Annual totals for the calendar year differ slightly from those plotted here[17] (17.9 inches instead of 17.8), but this diagram has certain advantages especially in giving a rough estimate of the amount of snowfall (October again is better included with summer since rain is more likely), and from this the degree of soil moisture recharge and the possibilities of a water surplus for the spring of that year. An average of 63 per cent of the total precipitation falls in the summer months, with only 37 per cent during the winter. Winter precipitation exceeded the summer total in 1963, the only year in which this occurred in the period of record.

Some knowledge of frost-free days and the length of the growing season would also be desirable when assessing an area's agricultural potential. These two parameters are depicted in Figure 8 firstly in their time of occurrence within the year (8a) and secondly in the total number of days (8b). The year 1944 was the mildest on record with the longest continuous period during which the mean daily temperature was above 42°F. and the second longest frost-free period. This year also had the highest mean annual temperature (Figure 5). Two years (1947 and 1949) had a frost-free period of just over 80 days which is reckoned to be very close to the minimum required for grain crops to reach maturity.[18] The frost-free period is, on average, 110 days long (from

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[17] Calendar year totals can be obtained from Appendix IV.

[18] C. C. Boughner and M. K. Thomas, op. cit., p. 14.

May 19th to September 6th) and the later decade shows a marked improvement in length over the first.[19] This seems to be a general trend throughout the province,[20] but the warming trend may possibly be a cycle which could suffer a reversal at any time. The length of the frost-free period compares quite favourably with the 106 days previously mentioned for the hilltop at Beaverlodge but it should again be stressed that the frost-free period is very susceptible to change even with minor topographic variations. These two meteorological stations would appear to have a rather longer frost-free period than most areas in the Peace River country. Goodfare, for example, about 20 miles west of Beaverlodge, has a frost-free period of only 61 days for the period 1951 to 1964.[21] As an extremely general statement it may be said that in the agricultural sector of the province the total of frost-free days varies from about 65 in the northwestern Peace River area to over 120 along the 49th parallel in the south.[22] Planting at the earliest possible moment and quick maturing crops are required for anything under approximately 85 days.[23] Early autumn frosts can cause a severe setback to crop yields and the

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[19] This is also shown in A. C. Carder, "Climatic Trends in the Beaverlodge Area." Can. Journ. Plant. Science, Vol. 42, pp. 698-706, October 1962.

[20] R. W. Longley, The Frost-Free Period in Alberta, 1965, p. 2.

[21] Ibid., p. 6.

[22] Deduced from a comparison of agricultural areas with R. W. Longley's map of average frost-free period.

[23] Calgary Power Ltd., Alberta, Province of Opportunity, 1958, p. 12.

years 1950 and 1952 were most noteworthy in this respect; especially 1950 in which severe frosts occurred between August 15th and 24th and large sectors of the Province were affected with yields reduced by at least a third.[24]

The growing season period was taken as the number of days between the time when a five-day moving mean of the mean daily temperature finally exceeded 42°F. in the spring to the first occurrence of a five-day moving mean below this value in the autumn. This can be a rather unsatisfactory measure especially in deciding the finishing point. It commonly happens that a warm period in October climbs above 42° again and in 1964 a period exceeding three weeks was, by definition, excluded from consideration. This final fluctuating period, on the other hand, may occur after a severe frost which would set growth back in any case so it is difficult to decide on a solution to this problem, particularly since frost susceptibility varies significantly with the different crops grown. Despite these disadvantages it is still a useful concept.

The growing season begins, on average, on April 28th but has varied from March 29th in 1944 to May 11th in 1961. The average closing date is September 27th with a variation from September 7th in 1964 to October 27th in 1944. . The average length is 152 days but the degree of variation according to site conditions is probably as great as is the case with the frost-free period. It would appear that, for an ideally sited meteorological station in the farming region of Alberta, the growing season will vary from an average of about 140 days in the north to

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[24]B. W. Currie, Prairie Provinces and Northwest Territories, Vegetative and Frost-free Seasons, 1954, p. 13.

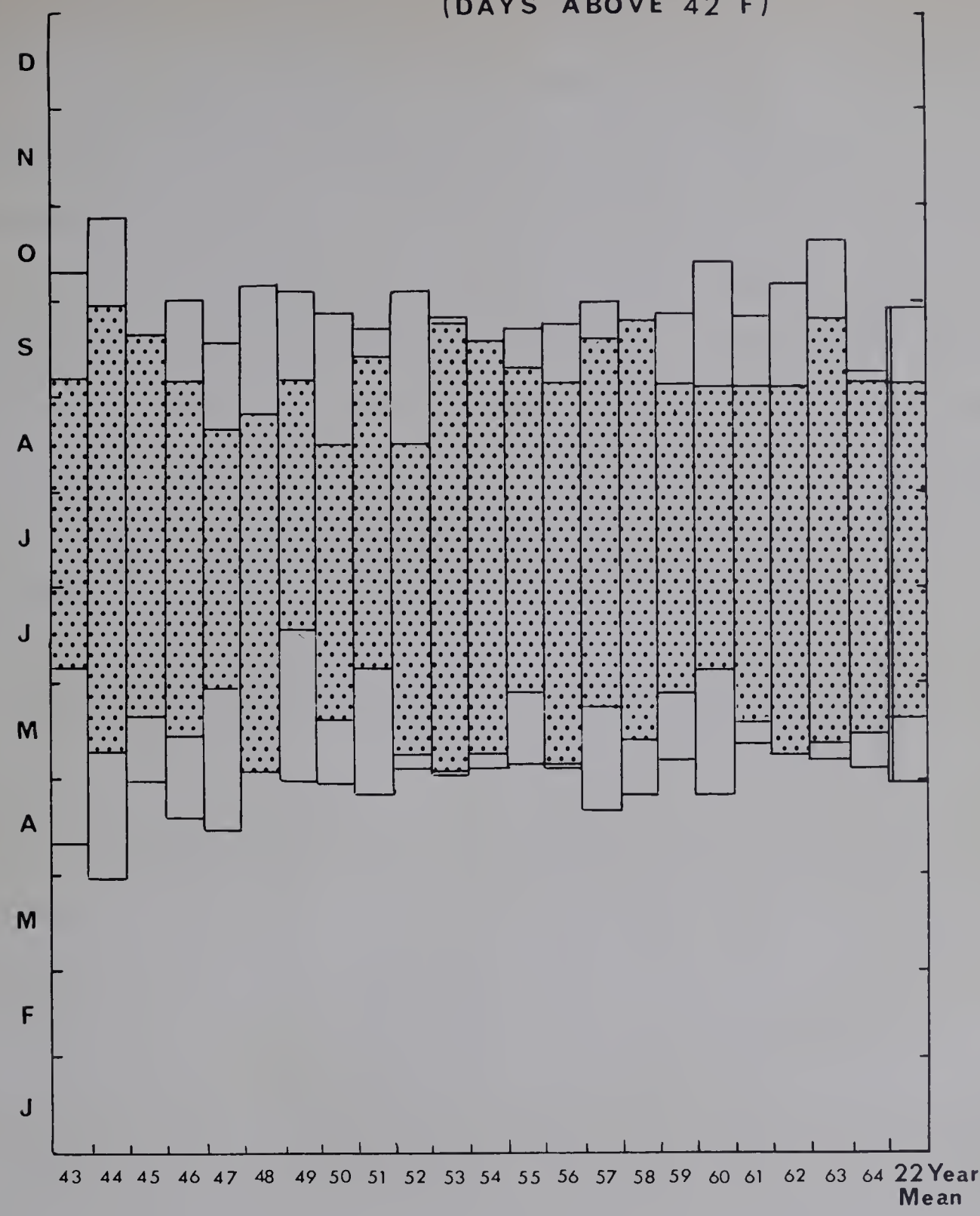


FIG. 8a

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	Mean	Median
Frost-free Days	93	141	122	115	83	115	81	89	99	99	144	131	105	93	118	132	100	89	108	117	136	114	110	111
Growing Season	183	212	142	166	125	155	156	150	150	151	147	136	138	142	163	148	143	169	137	150	165	127	152	150

FIG. 8b

Compiled from Dept. of Transport Monthly Meteorological Reports 1942-64 for Grande Prairie

about 190 days in the south.[25]

Perhaps an equally useful climatic statistic for agricultural purposes is one which illustrates the heat experienced during the growing season. A measure of accumulated temperature in degree-days above 42°F is helpful in indicating the warmth available for plant growth. When this is compared with frost-free days, actual evapotranspiration and deficit patterns, a good index of an area's suitability for agriculture, from a climatological point of view, can be obtained. Some values of accumulated temperature in degree-days for Grande Prairie are shown in Table I.

MONTHLY ACCUMULATED TEMPERATURES IN DEGREE-DAYS ABOVE 42°F FOR GRANDE PRAIRIE (1961-65)[26]

	J	F	M	A	M	J	J	A	S	O	N	D	Year
1961	-	-	-	28	330	581	632	657	177	139	1	-	2545
1962	-	-	-	48	230	454	568	520	274	63	9	-	2166
1963	-	-	-	39	236	468	617	597	471	98	2	-	2528
1964	-	-	-	8	232	458	538	458	137	124	-	-	1955
1965	-	-	-	32	217	442	643	639	120	68	-	-	2161
1943-65	-	-	-	41	285	440	586	501	280	65	6	-	2204

The average total over a period of 23 years is just over 2200 which is rather larger than indicated from other sources, especially

[25] Calgary Power, op. cit., p. 12.

[26] Data for 1961-1965 obtained from D. H. Smith, Regional Meteorologist, Department of Transport, Federal Building, Edmonton. The 1943-65 data were calculated from mean monthly temperature statistics for Grande Prairie and adjusted slightly through comparisons with the Department of Transport values.

those which are based on the standard period of 1921 to 1950. MacKay's data calculated for this latter period gives a total of slightly over 2000 degree days and the slight warming trend in recent years can help to account for the discrepancy.[27] In addition MacKay uses a standard period from the beginning of May to the end of September which is probably of help in rendering comparisons easier but it does not represent the whole period when the temperature is above 42°F. On his map Edmonton and Calgary are shown as having 200 degree-days more than Grande Prairie, Lethbridge 400 more, and Medicine Hat 1000 more. Obviously a combination of shorter growing season with lower temperatures makes the Peace River area less favourable for grain production than the other areas mentioned. It must be noted here that there has been an increasing degree of emphasis placed on the more hardy forage crops in the Peace River area since the 1930's. (See Appendix III) This may be a reflection on climatic conditions as well as improved marketing facilities for livestock.

Data for other climatic parameters within the area are not so readily available. The total number of sunshine hours per annum for Grande Prairie was not obtained but it is probably similar to the 2,110 hours received at Beaverlodge.[28] Sixty per cent, or 1,267 hours, occurs during the months of May to September when plant growth is most active. This varies little from points further south in the province, for example two other Dominion Experimental farms, at Lacombe

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[27] G. A. MacKay, 1965, op. cit., Map 7.

[28] A. C. Carder, Appendix. 1. Reconnaissance Soil Survey of the Beaverlodge and Blueberry Mountain Sheets, 1961, p. 108.

and Lethbridge respectively, receive 1,235 and 1,382 hours during these months.

Soil temperature records can be of considerable value since micrometeorological changes at ground level are influenced by this as well as by air temperature. In winter, with the blanket of snow that usually covers the ground, the soil temperature rarely falls below 20°F. and at Beaverlodge the period when the soil temperature was above freezing averaged 204 days, from about April 15th to November 5th.[29] Killing frosts recorded with thermometers four feet above ground level can have their effects minimized to some extent by this factor.

Wind has a considerable effect on crops, on soil, and also on evaporation. Wind speed however probably varies more than any other climatic factor with changes in aspect, altitude, and exposure. At Grande Prairie the annual wind velocity averages 8.7 miles per hour and varies from an average of about 7.5 miles per hour in the winter months to about twelve in May at a time when spring-seeded crops are most vulnerable.[30]

Only those facets of climate which can be expected to influence agriculture have been mentioned in this section (evapotranspiration will be dealt with later in the water resource chapter). Particular stress has been laid on the length of time available for plant growth, the moisture available in the summer period, and the degree of variation of

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[29] A. C. Carder. "Climate of the Upper Peace River Region." Canada Dept. of Agriculture Publication 1224, 1965, Figure 5, p. 10.

[30] W. Odynsky, A. Wynnyk, J. D. Newton, op. cit., p. 22.

temperature. Climatic conditions can also affect the soil itself as well as the vegetation which grows on it. Alternate freezing and thawing of the soil in spring and autumn can have a profound effect on structure. Chinook winds by baring the ground of snow and then raising the soil temperature can bring about the same result during the winter. These same winds can also cause water loss due to a winter thaw, which can reduce the amount that otherwise might have been available to plants later in the season. Water loss by runoff in the spring melt period can also alter the soil by erosion, a process aggravated by the relative impermeability of many Peace River soils. The strong west winds in the May period can bring about the same effect if unwise cultivation methods are practiced.[31]

(f) The Present State of the Land

Almost the whole area of the Spring Creek basin is covered by forest. Areas which are too wet for any type of tree growth and are therefore covered by sedge or moss muskeg are the major exceptions. Another exception is a small area about half a mile north of the junction of Wolverine Creek with the main stream. This area is used for summer cattle grazing by the Spring Creek Grazing Association and the tree growth has been kept down by man and by the cattle since the date of the last forest fire.

No major fires have occurred in the last 16 years, that is since the date of the air photos used in the compilation of the only published Forest Cover map of the area.[32] This showed major areas of scrub and

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[31] This paragraph contains a few statements from A. C. Carder, 1961, op. cit., p. 109.

[32] Forest Surveys Section, Alberta Dept. of Lands and Forests,

very young tree growth, some of which have been upgraded to tree standard in the map compiled for this survey (See Map 6 in the land resource chapter).

The forest therefore at the moment owes most of its variation in height and density to the age of the present growth. In some areas however it can be seen that density and species composition also vary with slope, soil, and drainage conditions. (See Photographs 8, 9, 13, and 25). Poplar, mainly aspen, at present covers most areas unless drainage problems arise. In these parts spruce becomes dominant, first white spruce where conditions are fairly moist, and black spruce where drainage is very poor.

Northern Canadian Forest Industries Ltd. (Grande Prairie office) hold logging leases for this area and was engaged in the selective cutting of balsam poplar in the Spring Creek "delta" area and the associated Simonette alluvial flats to the west in the winter of 1962-63. They have no further plans for logging since they have found no other timber of merchantable size.[33]

This company maintained the road in some state of repair until Water Resources began its Spring Creek research programme in 1965.

Map 83K/13. Scale 1:63, 360. Published 1953, air photos dated 1949.

[33]Personal communication from F. W. Bickell, General Superintendent, Logging Division, North Canadian Forest Industries Ltd., Grande Prairie.

CHAPTER TWO

THE LAND RESOURCE

The most important facets of the land resource that must be considered in any analysis for future utilization are the soil types, the slope of the land, the present vegetative cover and the drainage characteristics.

a) Soils

The Reconnaissance Soil Survey of the Grande Prairie and Sturgeon Lake Sheets extends sufficiently far south to include the Spring Creek basin on its published map at the scale of three miles to the inch.[1] However, a new soils map of the area has been done for this study (see Map 4), partly to obtain a detailed local knowledge of the area and partly to assist in the transfer of the previous one to a scale of 1:50,000 with the consequent addition of the smaller details that this scale makes possible. The same classification is used as in the Reconnaissance Soil Surveys so that comparisons can readily be made with other parts of the Peace River country through the use of the four surveys which have now been published.

The soils have been identified firstly on the basis of the major group i.e. Grey Wooded or Degraded Black, secondly on the basis of parent material, till or lacustro-till etc., and the final series name is given after consideration of other influences such as slope, drainage

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[1] W. Odynsky, A. Wynnyk, and J. D. Newton, Reconnaissance Soil Survey of the Grande Prairie and Sturgeon Lake Sheets. Research Council of Alberta, Report No. 74, 1956. Envelope in rear cover.

characteristics, and soil depth.

The most widespread soil is the Braeburn series of Grey Wooded clay loam found in the till plain area. In this region it has a higher proportion of stones than is normally the case in the Peace River country and this is indicated by the phase notation "st." in the large central section. Stones are also present in the large Braeburn area to the southeast but not enough to warrant an "st." designation in this case.

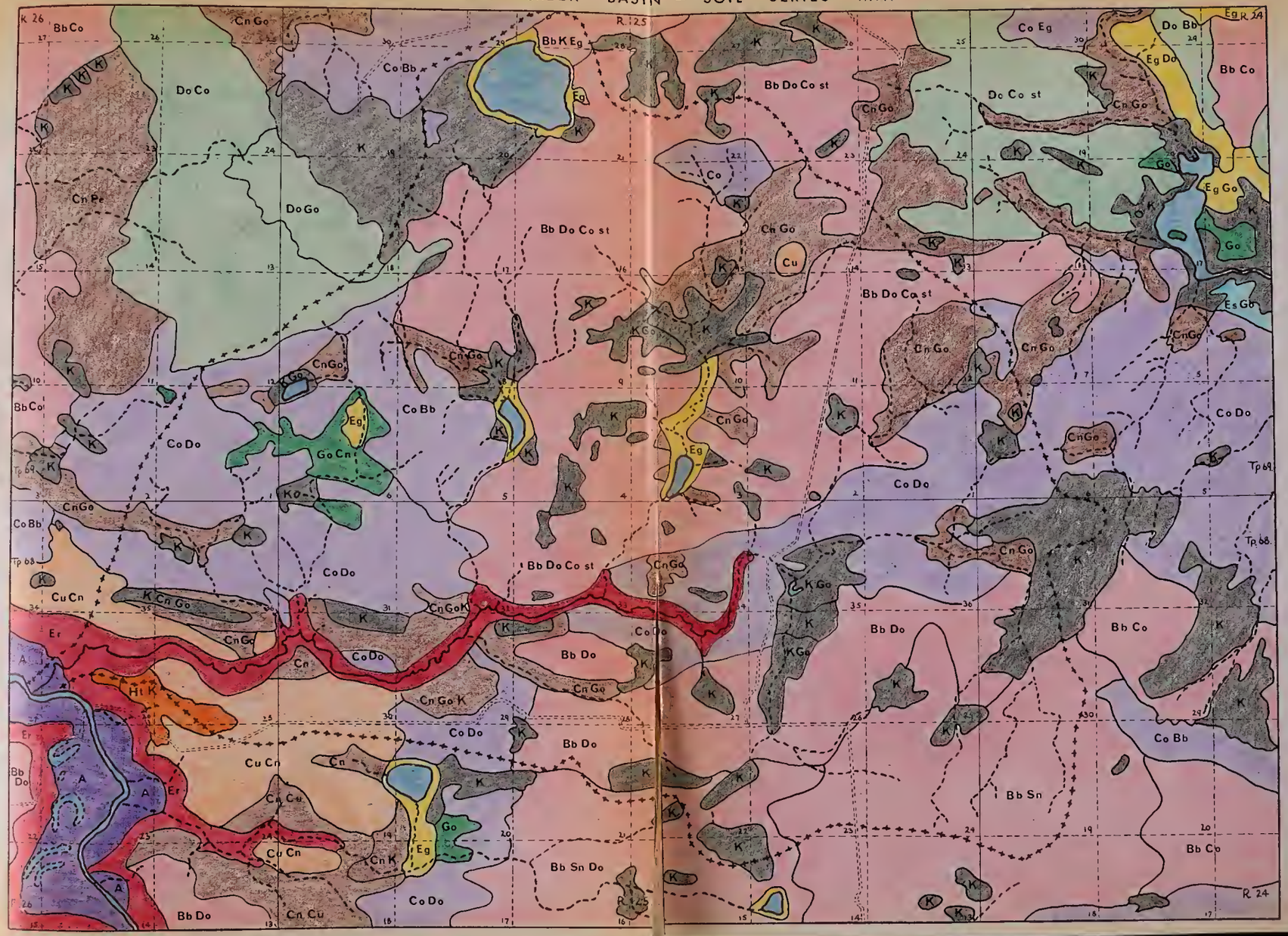
Very little of the land under this soil series is completely flat. It tends to be undulating to gently rolling. It is generally well drained with a tree cover predominantly of aspen. A typical area of Braeburn soil with recent forest regrowth can be seen in photo 2 taken about a mile north of the bridge across the creek. The stony nature of the parent material, as seen in the roadside cutting, would appear to extend at least to a depth of six feet. The following photo (No. 3) gives some indication of what such an area may look like when cleared for cultivation. The low organic content in the surface horizons (see photos 4 and 5--taken outside the basin) combined with the stony nature can detract from the economic possibilities of such a soil although these problems may be overcome by proper land management and by the periodic removal of surface stones.

In depression sites, particularly in the southeast, a peaty clay loam called Snipe is often found on the till surface.

The most common Grey Wooded soil which has lacustro-till as a parent material is a slightly solonetzic clay loam called Donnelly. The drainage characteristics of this soil vary from moderately well drained

MAP 4.

SPRING CREEK BASIN – SOIL SERIES MAP



KEY

TILL

Bb	BRAEBURN	Grey Wooded Loam to Clay Loam
Sn	SNIPE	Depression Podzol, often Peaty Clay Loam

LACUSTRO-TILL

Do	DONNELLY	Grey Wooded, a bit saline. Clay Loam to Clay
Es	ESHER	Degraded Black, a bit saline. Clay Loam to Clay
Go	GOOSE	Meadow. Drainage Problem. Clay Loam to Clay

ALLUVIAL – EOLIAN

Co	CODESA	Grey Wooded Sandy Loam to Silt Loam
Cu	CULP	Grey Wooded Loamy Sand to Sandy Loam
Cn	CODNER	Meadow. Drainage Problem. Sandy Loam to Silt Loam
Ht	HEART	Grey Wooded Sand to Loamy Sand
Pe	PEORIA	Degraded Black Sandy Loam to Silt Loam

ORGANIC

Eg	EAGLESHAM	Fine Peat. Mainly Sedge Origin
K	KENZIE	Coarse Peat. Mainly Moss Origin

Er	ERODED	Rough broken land adjacent to drainage courses
A	RECENT ALLUVIUM	River flat deposits

Base Map – Topographical Sheet 83K/13. D.M.T.S., 1960

to imperfectly drained. In the Spring Creek basin the tendency, because of the percentage of the land in slope, is toward a rather well drained soil. The most true to type sample of Donnelly soil is found on the lacustro-till area on the northwestern margin of the basin. In other areas, soils which appear to be lacustro-till tend to be gravelly or stony particularly in the northeast, so suitability for agriculture is somewhat impaired.

Donnelly soils, from the photographs included, are very subject to water erosion even on slight slopes (see photos 6 and 7). This point was also brought out by an answer to the questionnaire sent to District Agriculturists (see Appendix VIII, Grande Prairie office reply to question 17).[2] The uniformly sloping Donnelly area in the northwest is again the one to which this is most likely to apply.

A variation from the Donnelly pattern is lacustro-till on which has developed a Degraded Black soil called Esher but this occurs only on the eastern margin of the map and does not come into the basin itself.

In depressional sites a thin lacustrine deposit of more recent origin is often found. This is probably a relic of old beaver dams and is one way in which the heavy clay, poorly drained Goose soils are formed in this area. (See photo 8).

The main alluvial/eolian series is a Grey Wooded sandy loam to silt loam called Codesa. This is found on much of the sloping land (often long simple slopes) across the centre of the map leading down to the main

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[2] Water erosion on Donnelly soils was not so strongly stressed in the reply from the Spirit River District Agriculturist but the evidence seems to favour the view stated in the text.

creek, and it is also present locally wherever stream dissection and erosion have been sufficient to cause alluvial deposition in any stretch - the Simonette valley excepted. The lower areas in valleys in the large central portion of Braeburn soil are examples of this type.

In several areas, especially to the west of Wolverine Creek, the alluvial/eolian material may be quite thin on the summits of hummocks and the underlying lacustro-till material shows through.

Despite its often sandy or even gravelly texture Codesa soils may be poorly drained because of the underlying till and lacustro-till material which may be compacted, or within the zone of mineral accretion, so that vertical percolation of surplus water is impeded. For this reason marshy sites are still common on depressional areas near rivers and changes from the normal Codesa profile are often sufficient to warrant a separate series name--Codner. On photo 8 an area can be seen which will grade from Codner through to a heavy Goose soil and then to Kenzie.

Where the sand is deeper than is the case with Codesa a series call Culp has been mapped. This has a loamy sand to sandy loam type of texture and is often characterised by broken topography with fairly steep slopes and occasional depressions, possibly due to wind action in early post-glacial times. These depressions are marshy so Culp/Codner (Cu. Cn.) is a common grouping. Culp soils occur mostly in the area considered earlier to be predominantly covered by lacustine shoreline deposits. These soils stand out in air photographs as much lighter patches where the woodland is often more open than elsewhere and the drainage is nearly always excessive.

In one region Heart soils have been plotted. This is a Grey Wooded sand to loamy sand which covers the area where old U-shaped or hairpin dunes were identified in the surficial deposits section. They are now well stabilized with grass and an open aspen forest vegetation. (See photos 12 and 13). Between the dunes the hollows are generally occupied by organic deposits and the whole region has a more sandy appearance than the Culp soils which lie on three sides of it. The dunes are oriented with their steeper lee slopes to the east which is what would be expected in this part of the province since winds approximately from the west were dominant during their formative period.[3]

Peoria, a Degraded Black sandy loam to silt loam, is present along with Codner over quite a large area (more than two sections) in the northwest but outside the basin itself.

Stretches of muskeg are subdivided into Eaglesham or Kenzie soil series. The peat in Eaglesham organic soil is mostly composed of sedge and grass remains. Kenzie, on the other hand, is mainly composed of moss peat which is usually coarser and gives a more acid reaction than sedge peat. These two have been identified irrespective of the underlying material, which in any case only permits slow percolation and which is frequently identified as a grey clay on seismic shot-hole logs. Wet sedge meadows are sometimes drained for agricultural use although a very cold soil is produced. Muskeg terrain with spagnum moss cover is much less suitable.

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[3] C. P. Gravenor, R. Green, J. D. Godfrey; Air Photographs of Alberta. Research Council of Alberta, Bulletin 5, 1960, p. 20. W. Odynsky; U-shaped Dunes and Effective Wind Directions in Alberta. Canadian Journal of Soil Science, Vol. 38, pp. 56-62.

The only other soil subdivisions are Recent Alluvium (along the Simonette Valley), and Eroded, the rough broken land adjacent to drainage courses. The former series varies from gravel to a silty clay in the region where Spring Creek flows into the Simonette. (See photo 11). The drainage in the gravelly areas is usually good but some of the land is subject to periodic flooding. Several oxbow lakes on this floodplain are in the process of silting up or being infilled by organic material.

It should be noted that many of these soils are dominant series in an area. They are members of an associated group of soils present because conditions are seldom uniform over a wide area. Some common groupings are Bb. Do. Co which has been mentioned previously in the surficial deposits section (Bb. on the till surface, Do. where there is evidence of lacustro-till, and Co. where alluvial sorting has occurred in the valley bottoms), Cn. Go., Cu. Cn., and Co. Do. Only a few examples can be found where one series is present to the exclusion of all others e. g. Kenzie or Eaglesham.[4]

b) Slopes

The degree of slope of an area is an important aspect in any land use plan where conservation is emphasized. In Alberta soil surveys have made use of a slope classification with five basic categories and these have been retained and used in the compilation of Map 5.

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[4]Extensive use has been made throughout the soils section of series descriptions contained in W. Odynsky, A. Wynnyk, and J. D. Newton 1956 op. cit., pp. 39-94. Specific examples were then drawn from the Spring Creek basin area.

The base map from which the slopes were measured was a twenty foot contour interval map of the basin at a scale of one thousand feet to an inch. This enabled extra slope detail to be added to the previous slopes map available from the Sturgeon Lake soils sheet at a scale of three miles to the inch.[5]

The area in the level and undulating category is 20.7 square miles or 49 percent of the basin area. The slopes vary from almost completely level areas, many of which are marshy (section 20 Tp. 69, R. 25), to long smooth slopes with a gradient of up to 1.5 percent. Undulating areas with a few long slopes, but mostly composed of minor irregularities and swells, have been placed in this category if the slopes do not exceed two percent. Large areas along the eastern margin of the basin are of this type.

The category which is designated "gently rolling" overlaps slightly with the level to undulating land and also with the category which follows it in degree of slope. Some measure of overlap was recommended in the report of the National Soil Survey Committee for a number of reasons.[6] For instance, erosion characteristics can vary between a two percent slope present for a few yards on either side of a

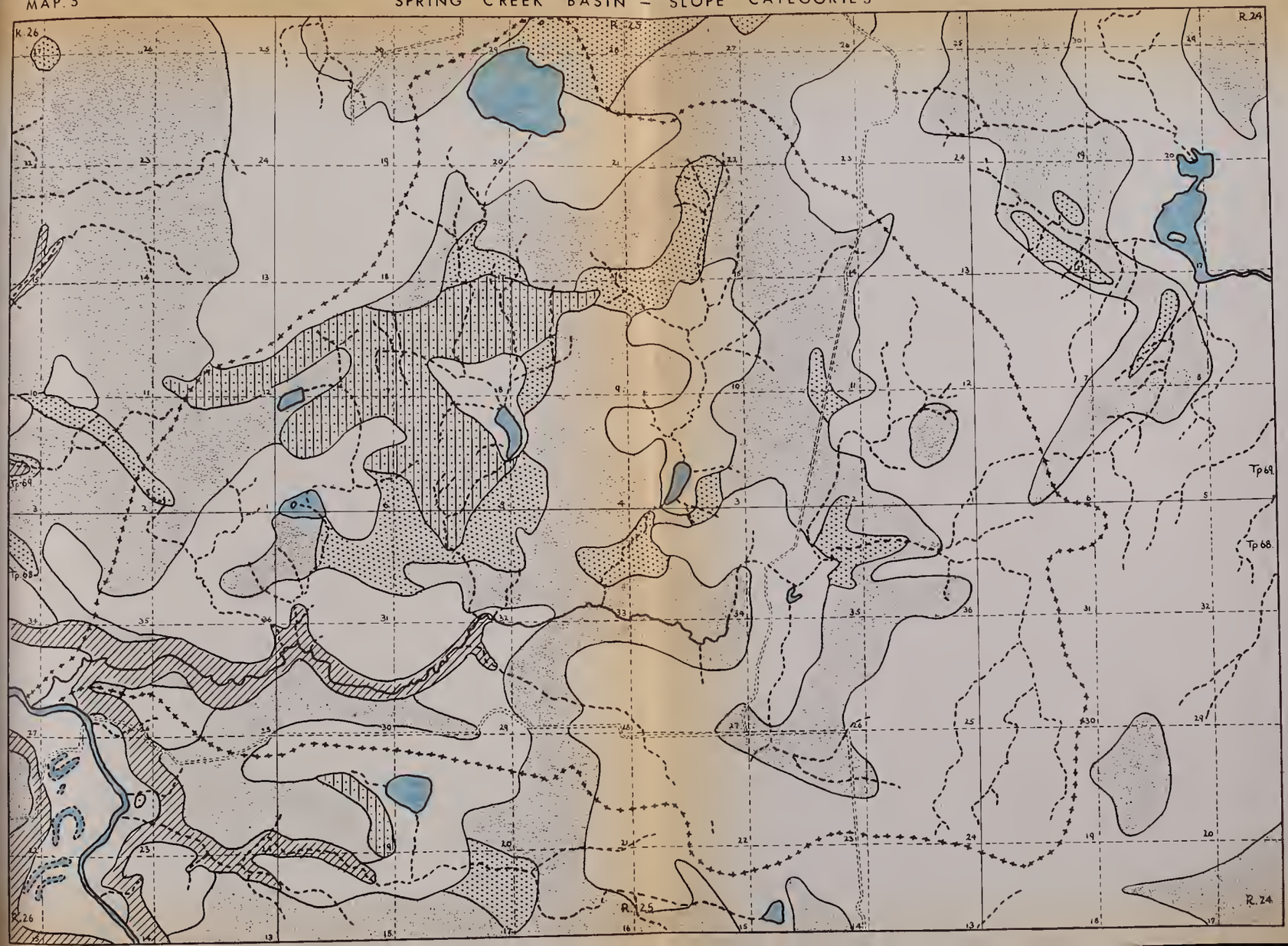
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[5] Ibid. envelope in rear cover.

[6] Proceedings of the First Conference of the National Soil Survey Committee, Ottawa, Ontario. May 7-11, 1945. Discussion by Dr. C. E. Kellogg, p. 69. All the Peace River area reports use this system of classification but it must be mentioned that classes do not overlap in some later reports for other parts of the province. These reports use later proceedings such as Fifth Conference of the N.S.S.C., Winnipeg, Manitoba, March 4-8, 1963.

MAP. 5

SPRING CREEK BASIN – SLOPE CATEGORIES



KEY

- LEVEL AND UNDULATING
- GENTLY ROLLING
- ROLLING
- HILLY
- ROUGH BROKEN LAND ADJACENT TO DRAINAGE COURSES

Base Map – Topographical Sheet 83 K/13. D.M.T.S., 1960

slough and on a hillside which might have this steep a slope over several hundred yards. The momentum which can be built up by runoff water in the latter case can make it more subject to erosion in its lower reaches than a short, equally steep slope. It is therefore placed in a higher slope category. Hence gently rolling land is taken as indicating regions where long smooth slopes rarely exceed six percent but the more irregular ground with variable slopes may contain limited amounts of land with slopes as great as nine percent. The amount of land in this category is 14.3 square miles or 33 percent of the basin area. It is mostly distributed between three north-south trending areas which, however, do not separate any distinct terrace levels.

Only a small percentage of the area of the basin is too steeply sloping to be included in these two categories. This was illustrated previously in the diagram of average slopes (Figure 3) and the distribution of these areas can now be seen on the map.

Areas which have slopes greater than the limit of the gently rolling class, but are still less than fifteen percent, are classified as rolling. Included are slopes between six and fifteen percent for long uniformly sloping areas and between nine and fifteen percent for broken land which is a succession of knolls and depressions. The kame moraine area to the east of the lake in section 21, Tp. 69, R. 25 has slopes of this type. A few of the incised river valley slopes are also included and the only major area with a long uniform slope is in sections 9, 10 and 15 of Tp. 69, R. 25.

In the Sturgeon Lake report land with slopes which are classified as rolling is considered to be usable if other conditions are

favourable.[7] The slightly higher rainfall of this region in relation to settled areas nearby, combined with the extent of heavy clay underlay particularly in Codesa areas, are factors which could be considered as meriting the designation "unfavourable". This aspect, however, will be dealt with later in the section on erosion in Chapter IV.

Only eight percent of the basin area is in this category--a total of 3.3 square miles.

Slopes which are greater than fifteen percent are usually classified as hilly land. This is considered to be non-arable. Erosion caused by spring runoff and summer rainfall would soon ruin the land and, in any case, it is too steep for most mechanised methods of cultivation. The region of concentric ridges and the associated steep southeastern face below the lacustro-till area in the northwest is the only hilly area within the basin. Even clearance for grazing could have serious repercussions in an area like this. The effects of heavy grazing on similar Codesa soils with lesser degrees of slope can be seen in photos 26 and 27. Seven percent of the basin is hilly land.

The only other subdivision to be mapped is described as "rough broken land adjacent to drainage courses." The slopes here can be quite variable - anything from ten percent to over forty percent. In the Spring Creek basin area it is not suited to arable use since slumping is fairly common in wet years even under a forest cover. Within the basin only the slopes adjacent to the lower reaches of the main stream are steep enough to be included in this category. The actual area involved is therefore quite small - only one square mile or two percent of the basin

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[7] W. Odynsky, A. Wynnyk, and J. D. Newton, 1956, op. cit., p. 36.

area.

A small fraction of the basin, just over one percent of the 43 square miles, is covered by water. This can fluctuate to some degree. The small lake on Bridle Bit Creek is especially prone to variation since it can vary greatly in area from that shown on the map with only a small rise in level. Two other lakes, one on Spring Creek just east of the road crossing, and the other on Wolverine Creek in the south-western corner of Tp. 69, R. 25, owe their existence almost entirely to beaver dams. If these were removed the lakes would be considerably reduced in size. These two lakes did not exist when photography was flown for the topographical map compilation (1954) so they have been omitted from most maps in the text but can be seen on the slopes map and also on the forestry map.

c) Forest Cover

The potential for future use of this area may be deduced to some degree from a map of the present cover. Slope and drainage characteristics influence tree species, tree density, and tree height. The soils with adequate moisture storage capacities and with no danger from waterlogging carry the densest stands but these, therefore, may also be among the most expensive areas to clear. However, in this area any analysis of soil, slope, and drainage must first deal with the difficulty of tree age and species as influenced by fire.

Air photographs taken in 1965 were used by the Forest Surveys Branch of the Alberta Department of Lands and Forests in the compilation of Map 6 at the request of the Water Resources Branch. Each mapped area contains a code of which the first letter signifies the density

subdivision as explained in the key. This is followed by a number whose value represents the height category - category one includes trees up to thirty feet high, two includes trees between thirty and sixty feet in height, and three indicates heights of between sixty and eighty feet. No areas large enough to be mapped were covered by trees higher than eighty feet. After the number is placed the code letter or letters identifying the tree species. The most common category, that of deciduous trees (mainly aspen) is designated A, conifers (mainly spruce) are separated into Sw. (white spruce) and Sb. (black spruce).

The map has been coloured to show the species composition--two shades of brown for white and black spruce, and green to represent areas where poplar (mainly aspen) is dominant. The poplar areas vary greatly in tree height so the green is further subdivided--the lightest shade showing the smallest trees (i.e. those under thirty feet in height) and the darkest shade for the tallest. Some of the differences in the aspen cover can be seen in photos 2 (BIA), 9(B2A, then C2A), 13(BIA), and 25 (C2A).

On the official forest cover map published by the Department of Lands and Forests from 1949 photographs,[8] nearly all the low poplar in the east was classified as recently burned land, potentially productive in the future. No major fires have occurred since 1949 so these areas with their present cover of medium stocked deciduous trees less than thirty feet in height (BIA) represent at least seventeen years of forest recovery.[9]

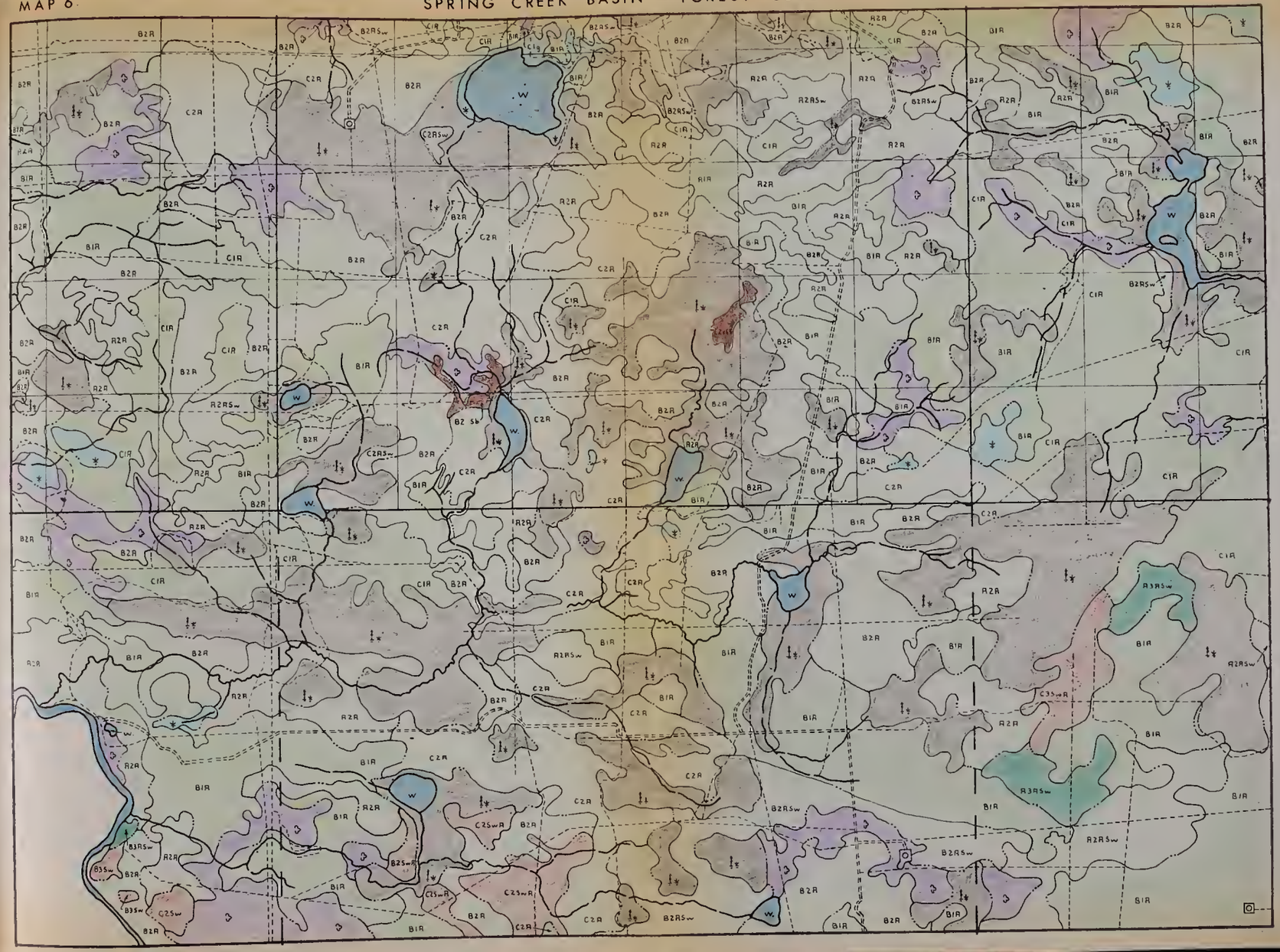
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[8]Alberta Forest Cover Series. Sheet 83 K/13. Scale 1:63, 360, published 1953.

[9]Personal communication from Mr. Roy Bastian, Construction

MAP 6

SPRING CREEK BASIN — FOREST COVER



KEY

BLACK SPRUCE DOMINANT

WHITE SPRUCE DOMINANT

DECIDUOUS DOMINANT (POPLAR)

DECIDUOUS (Up to 30 feet)

DECIDUOUS (31 - 60 feet)

DECIDUOUS (61 - 80 feet)

SCRUB, BRUSHLAND

OPEN MUSKEG

TREED MUSKEG

WATER

DENSITY SUB-DIVISIONS

A - SPARSELY STOCKED

B - MEDIUM STOCKED

C - FULLY STOCKED

D - OVERSTOCKED

Mapped by Forest Surveys Branch, Dept. of Lands and Forests from 1965 photos.

Areas classified as scrubland do not always upgrade themselves to low deciduous cover. This is a category based mainly on site characteristics, so drainage and soil conditions in those areas inhibit normal tree growth to such an extent that a low brush cover results. Excessively stony ground or wet conditions which favour phreatophytic willow growth are two reasons for the presence of this low brush.

Open muskeg in some parts of the mapped area (around the large lake and in the northeast corner) covers areas previously mapped as Eaglesham soils. The coincidence, however, is not complete since other forms of open muskeg, i.e. moss but no trees, are also common.

The area shown as treed muskeg is generally similar to that mapped as Kenzie, or moss, organic soils on Map 4. However, the interpretation of areas in this category seems rather generous on the forest cover map, particularly near the mouths of Wolverine Creek and Rocky Creek where stretches mapped as muskeg are actually used for cattle grazing. It is usually the case that where some difference is present between the two maps the same area on the soils map is classed as Codner, Goose or some combination that indicates drainage problems.

The forest distribution mapped for this basin illustrates quite well the pattern described for the mixed-wood section of the Boreal Forest to which the area belongs.[10] The environment is most favourable for white spruce and this establishes itself under a deciduous cover which it eventually

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Section of the Alberta Forest Service, Dept. of Lands and Forests.

[10]Alberta Department of Lands and Forests, Forest Survey Branch. Alberta Forest Inventory. Nov. 1961, p. 24.
J. S. Rowe, Forest Regions of Canada. Canada Department of Northern Affairs and National Resources. Forestry Branch - Bulletin 123, Ottawa, 1959, pp. 22-23.

replaces as these trees become older and deteriorate. The most characteristic deciduous trees are aspen poplar and balsam poplar, the latter often being dominant on more moist lowland sites (the Simonette valley), and the former in the better drained higher areas. Large stretches of the north-central part of the province have been subjected to repeated fire damage in the past so a deciduous cover is still common and replacement by conifers is only progressing slowly. A few small patches to the south of the basin have white spruce shown as the dominant species present, and in some areas which do have a mature deciduous cover white spruce is included in the classification notation on the map.

There is a tendency for Culp and Heart soils to have an aspen cover classified either as B1 or A2 i.e. it is sparse and of moderate height or it is low but thicker. In each case this reflects the relative lack of water in the root zone compared with other soil series. Codner and Goose soil areas are commonly classified as treed muskeg, or scrub, or low poplar (B1A) but this is by no means universal. Some gravelly or sandy Codesa areas, especially in the west and the small patch in the north centre, also have rather low growth but with a great variation in density. No assessment can be made of forest conditions as related to soil series in the east because of the recency of fire damage. On Bb. Do. Co. soils B2 and C2 categories of aspen cover are most common. It is not mature enough to be marketable but it is high and dense enough to make clearance expensive.

One of the major points of interest which will probably arise from the forest cover map in the future is the difficulty, or otherwise,

of clearing for agriculture. Clearance costs are influenced by the slope of the land, and by the shape and size of the plot to be cleared--the flattest, most regularly shaped plots being the most economical and the costs becoming less per acre as the acreage increases. The primary control over feasibility, however, is the density and height of the tree cover. In one Department of Lands and Forests publication the following assessment was given of the costs which would normally have to be faced to bring a half-section unit into production.[11]

Clearing	240 acres at $15.00 = $3,600
Breaking	240 acres at $ 9.00 = $2,160
Root Picking	240 acres at $ 5.00 = $1,200
Preparing for crop	240 acres at $ 5.00 = $1,200
Burning brush piles and clean up	240 acres at $ 4.00 = $ 960
Total	= $9,120

This amounts to a total cost of $38 per acre. A farmer can cut down on this appreciably by doing the burning, root picking, and ground preparation himself but the initial outlay for getting a contractor to clear and break the land is still at least $24 per acre and this is unlikely to decrease in the years to come.

Many homesteaders, of course, do not clear as much as this in one operation. They may prefer to do it in amounts of ten acres or more for each quarter section, and much if not all of this may be done

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[11] W. Odynsky, C. D. Sawyer and V. A. Wood. Public Lands Open for Settlement in the Peace River District of Alberta. Alberta Dept. of Lands and Forests, May 1964, p. 6.

by themselves. This permits a person to start with much less capital but the return in each year for at least the first five or six is also very small. It has often been the case, therefore, that fairly desirable soil areas with a heavy tree cover have been left while other less favourable areas with a light tree cover have been opened up irrespective of their soil quality. In this basin the soil is not very fertile initially and if heavy clearance costs must also be faced as well as possible marginal climatic conditions, then some form of government assistance may have to be envisaged. This would help to tide the land occupant over the period of breaking and would assist him in the initial payments for his investment in building supplies, machinery, livestock, water, etc.

In one of the soil survey reports some discussion is made of the point that it may be possible to operate a programme of supervised and controlled burning, especially for any of the more fertile areas with a dense tree cover.[12] This could be supplemented by the seeding of these burnt-over areas to a grass-legume mixture which would give relatively open areas at low cost and which could provide some basis for the livestock economy to which this region may be best suited. Controlled burning, however, has not been undertaken to any great extent except in the clearing of the scrub cover from community pasture land.[13]

For some of the more sandy areas, it has been suggested that to

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[12] W. Odynsky et al. Reconnaissance Soil Survey of the Beaverlodge and Blueberry Mountain Sheets, 1961, p. 99.

[13] Information received from staff in the Public Lands Homesteading Section, Lands Division, Alberta Department of Lands and Forests.

avoid possible damage from erosion the seed of cultivated grass species could be scattered through the area and the less palatable native grasses could therefore eventually be replaced without the ground cover being broken at all.[14] This could be a useful method but again mainly in the establishment of permanent pasture.

d) Drainage Considerations

When soils are well drained the action of the climate and the vegetation over a long period of time gives rise to distinct horizons. Where drainage conditions are poor distinct horizons can again be formed but related more to the effect of local site characteristics than to the overall climate and vegetative controls. Many of the soils in the Spring Creek basin area have been more affected by local drainage conditions than by climate and vegetation and correlations are now drawn from the soils, slopes and vegetative cover maps to illustrate where drainage problems are present and how they might be identified.

Only a minority of the soils in the basin suffer from impeded drainage. Land under Bb. Do. Co., Do. Co., and Co. Do. soils is often slightly sloping. Drainage is therefore quite good and this is also true where these soil combinations are present on the flatter interfluves in the east, particularly since the most frequent forms there are Co. Do. and Bb. Co. The high percentage of sand in the Codesa helps to accelerate drainage although it may not percolate deeply and may move laterally above the heavy subsoil to collect in a local slough or evaporation basin.

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[14] See Appendix VIII. Grande Prairie District Agriculturist's questionnaire reply to question 4.

In sections 4, 5 and 6 of Tp. 69, R. 24 Codesa is the dominant soil series but, in any of the hollows into which the water may move, Codesa gives way to Co. Cn., Cn. Go., or Kenzie, depending on the supply and detention of the water available.

Tree species can give some indication of drainage conditions. White spruce is the probable climax vegetation of this area, but after its destruction by fire, it takes varying lengths of time to re-establish itself depending on site conditions. Moist but well drained soils are preferred,[15] so it is interesting to note that replacement has progressed to the greatest degree in the south and southeast where moist conditions are indicated by the presence of Snipe soil series in a predominantly Braeburn area. White spruce is not found in the peaty Snipe depressions but rather on the gentle slopes leading down to the depressions which themselves are sometimes open or tread muskeg.

Black spruce is usually indicative of very poor drainage conditions. It is a characteristic tree of muskegs and in two poorly drained areas it occurs in a sufficiently pure and high stand to be plotted separately.

Some areas of treed muskeg have been plotted on the forest cover map which do not correspond with Kenzie on the soils map.[16] A comparison with the slopes map shows that some of these differences are on sloping ground. Some degree of drainage impedance would

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[15] L. Sayn-Wittgenstein. Recognition of Tree Species on Air Photographs by Crown Characteristics. Canada, Department of Forestry, Technical Note No. 95, 1960, p. 22.

[16] Examples of this occur in section 36, Tp. 68, R. 25 and sections 2 and 3 of Tp. 69, R. 25.

therefore appear to be possible on sloping ground under certain circumstances and it would appear that aspect may be involved here since west and north-facing slopes are most commonly affected.

True muskeg is never present except in the category of slopes classed as level to undulating. Some isolated patches are present in areas that have been placed in a higher slope category but the muskeg occurs in the hollows in the undulating terrain. The kame moraine on the northern margin is a good example.

Two other soil series can also be used as indicators of poor drainage conditions. Goose and Codner soils are present, like muskeg, mainly on level land. Soils belonging to the Codner series can also be found in gently rolling terrain, for instance in hollows where Culp is the dominant series or an even steeper category than this but the valleys are flatter and water is concentrated here with a relatively slow rate of release from the efficient detention storage provided by the tree and sedge cover. Beaver dams can be an additional cause in arresting flow and in assisting the formation of these soils in such sites.

In the southeast the presence of Snipe soils suggests some lack of surface drainage in the flatter areas. The slope of the Bb. Sn. area is almost always less than two percent and wherever the slope category changes to something steeper, i. e. to the west or to the extreme southeast, the soil changes to Bb. Do. or Bb. Co. with the peaty Snipe hollows disappearing.

In the northwest there is a small area of Donnelly/Goose soils. This is found where the surface is almost level, just at the edge of the region's largest stretch of muskeg. The land then begins to slope to the

west and northwest and immediately this slope becomes apparent the Donnelly/Goose association is replaced by Donnelly/Codesa.

The Codner/Peoria region downslope from the lacustro-till also has an average slope greater than two percent. However, here there are numerous valleys and hollows where Codner is most common while Peoria soils are present on the higher and more sloping ground.

CHAPTER THREE

THE WATER RESOURCE

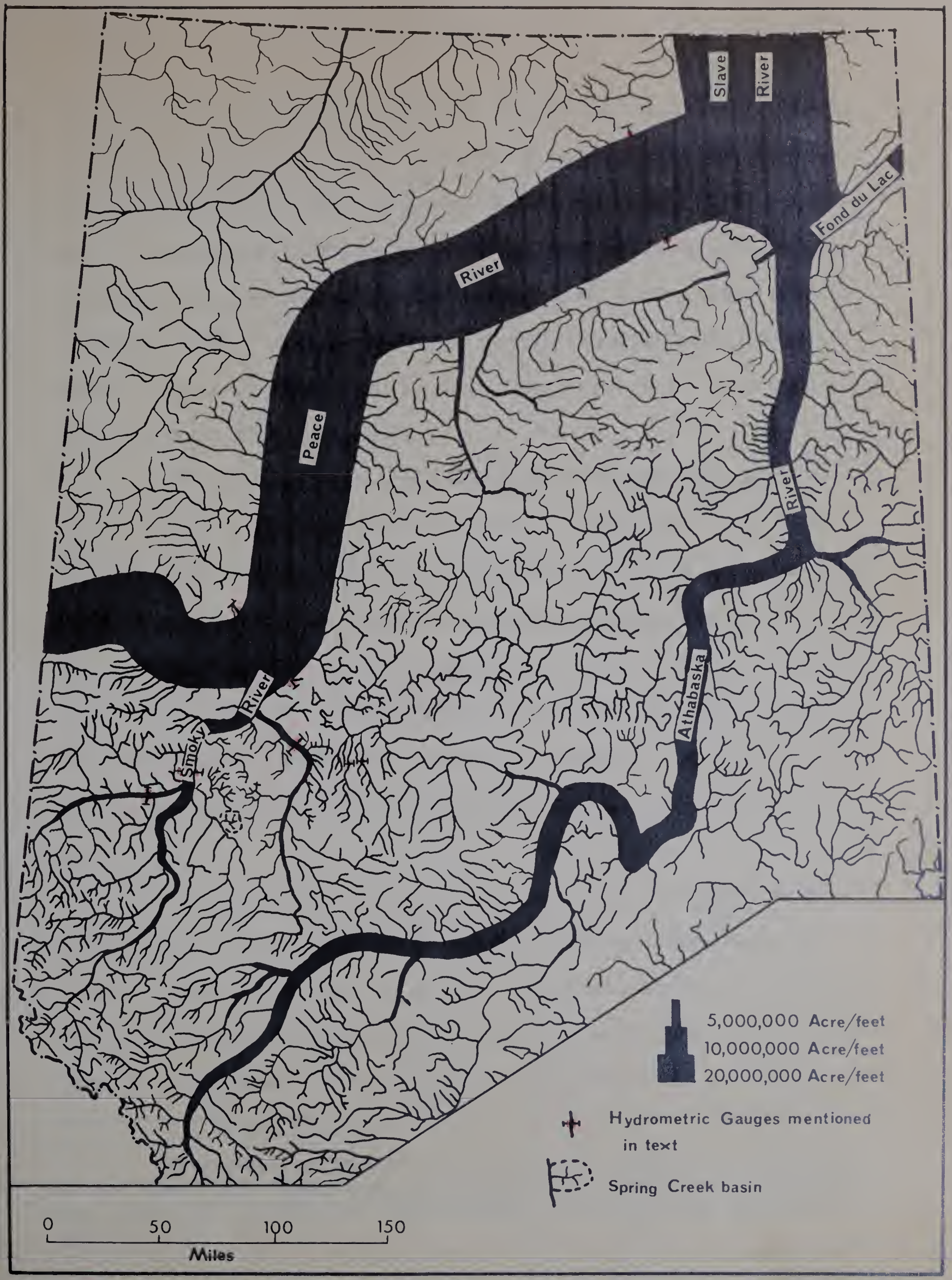
a) Flow Patterns in Northern Alberta

Before considering various aspects of the water resource of Spring Creek basin this subject should be placed in its proper perspective by giving a general introduction on streamflow patterns in the northern half of the province. Since no records are available for Spring Creek a comparison with the few streams which do have records will give a clearer picture of the yield to be expected and the season of major flow.

The main streams of Northern Alberta are shown on Map 7. The Slave, Peace, Athabaska, Fond du Lac, and Smoky outrank all other rivers in total annual yield. Spring Creek is evident as a relatively insignificant tributary of a comparatively minor stream, the Simonette. These major streams, however, are eventually all supplied by numerous individually insignificant tributaries which in total are of very real importance in any water balance studies.

The amount of flow in some northern rivers is also illustrated in Table II. The Peace River at Peace Point, about 145 miles upstream from its junction with the Slave River, has an annual flow about five million acre-feet in excess of that at Peace River town when averaged over the last five years. The average depth of runoff over the basin, however, is very much less. This indicates that the addition in size to the basin downstream from the town does not add a commensurate amount to streamflow. Even in the long term view when records at Peace River are analyzed over twenty two years (instead of the last

MAP 7. NORTHERN ALBERTA — STREAM NETWORK



Source – A.G. Underhill, Calgary Office, Water Resources Branch.

five which were wetter than average) there is an average contribution of over ten inches of water from all of the basin upstream from this point. The maximum flow occasionally occurs in May but more usually in June and is from the snowmelt in the mountain headwaters. The snowmelt from various altitudes and aspects takes place at different dates so this, combined with the summer precipitation maximum, helps to give a more sustained summer peak than is the case with most of the streams discussed later.

The average water yield of the Smoky River basin above Watino in the five year period 1959-64 was 9.76 inches. The high value is again indicative of a stream receiving its major volume contribution from the higher precipitation and lower potential evapotranspiration of mountain areas and this picture is further accentuated by the high basin contribution of the Wapiti. It does not drain any larger a mountain area but, because a smaller proportion of its basin is in the plains, the mountain contribution has not been "diluted" to the same extent.

An interesting comparison can be made between the Wapiti and the Little Smoky rivers. The basins at the gauging points are almost the same size but because the Wapiti drains a sizeable mountain area whereas the Little Smoky does not, its contribution per unit area is much larger.[1] The snowmelt runoff, since the rivers are

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[1] The years of record are different but the period of overlap shows this trend. Contribution per unit area--Wapiti, 11.88" (1961-62), and 10.56" (1962-63); Little Smoky, 7.39" (1961-62) and 6.56" (1962-63).

shorter and a larger proportion of their area is in the foothills, gives a flow maximum earlier in the year than is the case with the Peace. The Little Smoky has an earlier peak than the Wapiti probably since a much greater proportion of its basin area in the foothills and the snowmelt is not so protracted there as in the mountains. On both streams there are occasional July maxima--the Little Smoky for 1961 and the Wapiti for 1964, both years having had heavy June precipitation.[2]

These are the available records for the major streams near Spring Creek. No data have been recorded for the Simonette but it is likely to resemble the Little Smoky more than any of the other streams discussed. Spring Creek, however, does not rise in the mountains nor even in the foothills so the contribution to streamflow per unit area is almost certain to be much less than all of those mentioned earlier. Data for the two smaller rivers in Table II, the East and West Prairie Rivers, may provide a more realistic comparison although by no means ideal since they rise in the Swan Hills (see Map 1). Snowfall is less than in the mountains but the local intensification of precipitation in the Swan Hills area is likely to result in a higher yield per square mile than would occur in the Spring Creek basin. The extensive forest fires in the north-western part of the Swan Hills in the 1940's and 1950's should widen the gap still further.[3] It would appear therefore that water yield from the

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[2]The precipitation at Grande Prairie in June 1961 was 5.20" and in June 1964 it was 6.32".

[3]Alberta Department of Lands and Forests, Forest Classification Map. Published in 1957 at a scale of sixteen units to the inch.

TABLE II

STREAMFLOW PATTERNS IN NORTHERN ALBERTA

	Peace River at Peace Point (113,000 sq. miles)		Peace River at Peace River (72,000 sq. miles)	
YEAR	Runoff in acre/feet	Depth in inches for Basin	Runoff in acre/feet	Depth in inches for Basin
1959-60	59,320,000	9.84	53,600,000	13.96
1960-61	47,930,000	7.94	41,890,000	10.91
1961-62	60,580,000	10.04	51,440,000	13.39
1962-63	57,300,000	9.37	55,480,000	14.44
1963-64	69,410,000	11.51	66,780,000	17.39
Five year Average	58,908,000	9.70	53,838,000	14.02

	Smoky River at Watino (18,500 sq. miles)	
Year	Runoff in acre/feet	Depth in inches for Basin
1959-60	10,830,000	10.97
1960-61	5,063,000	5.12
1961-62	10,000,000	10.13
1962-63	9,596,000	9.72
1963-64	12,680,000	12.84
Five year Average	9,635,800	9.76

TABLE II (Continued)

Year	Wapiti River near Grande Prairie (4,350 sq. miles) Runoff in acre/feet	Depth in inches for Basin	Little Smoky River at Guy (4,130 sq. miles) Runoff in acre/feet	Depth in inches for Basin
1959-60	--	--	1,027,000	4.66
1960-61	--	--	558,000	2.53
1961-62	2,758,000	11.88	1,630,000	7.39
1962-63	2,458,000	10.56	1,448,000	6.56
1963-64	4,008,000	17.28	--	--
Short term Average	3,074,666	13.24	1,165,750	5.29

Year	East Prairie River near Enilda (500 sq. miles) Runoff in acre/feet	Depth in inches for Basin	West Prairie River near High Prairie (430 sq. miles) Runoff in acre/feet	Depth in inches for Basin
1960	108,900	4.08	71,530	3.11
1961	106,400	3.98	54,110	2.35
1962	184,500	6.90	153,200	6.67
1963	163,600	6.13	102,900	4.48
1964	261,500	9.80	212,100	9.24
Five year Average	164,980	6.08	118,770	5.17

Source - Department of Northern Affairs and National Resources, Water Resources Branch Records.

Spring Creek area in the five years prior to 1965 should be estimated at less than an average depth of five inches over the basin, probably 3.5 inches would be a reasonable estimate from this data. The snowmelt runoff peak can be expected in April or in May, with a tendency in some years to a supplementary high in June, July or August if summer rains have been exceptionally heavy.

b) Some Characteristics of the Spring Creek Basin.

No detailed streamflow or precipitation measurements are available for any area close to the basin so water balance patterns have to be analyzed by some other method. Some discussion, therefore, of basin characteristics which can influence the water balance should be included at this point.

The vegetative cover has been described in the previous chapter. Its variations in depth and density can be expected to cause variations in plant consumptive use. The deeper rooting habit of the more mature trees ensures that more water is available to them during any summer deficit period so that greater moisture supplies are needed in the following spring to fully recharge the soil. As a result there is a smaller contribution to surplus than from areas where the cover has a shallow root system.

The sloping topography over parts of the basin increases the potential for overland flow and decreases the surface detention during periods of high rainfall intensity or rapid snowmelt. This, in consequence, is an obvious case where land should be left under as dense a vegetative cover as seems necessary to control erosion, gentle slopes being covered with grass and the steeper slopes left under forest.

The tendency of the sloping land to give a quick response in streamflow at times of water excess may be offset by the numerous muskegs and minor internal drainage basins which give good detention storage on the interfluves and on many of the upper reaches of the tributaries. The delaying action of the marshes along the streams, however, may not be so efficient as is sometimes supposed since they are usually at field capacity already and any delay is mostly caused by water being spread over a wider area for the initial flood period rather than being absorbed or detained by the marsh itself. The isolated sloughs, muskegs, and water bodies (such as the large lake near the Rocky Creek headwaters) can retain considerable amounts of water before overflow takes place but if it does, flood crests can be considerably augmented since the area contributing runoff to the stream is suddenly increased. The normally non-contributing areas will therefore under most conditions lengthen the basin lag time and even out flood crests until overflow from all of them takes place.

Soil texture relationships to infiltration capacities and to soil moisture detention and retention storage rates are very significant. Much of the soil within the basin is either stony or sandy so a smaller percentage of the total precipitation can be held for plant use than is the case with a clay soil. The volume of runoff is therefore greater from these areas but nearly all of this, especially on sandy soil, can be in the form of interflow and groundwater contribution rather than surface flow. The presence of a less permeable clay subsoil, however, may delay percolation to depth in parts of the basin, so if the soil above

this less permeable layer becomes saturated there may be a tendency towards erosive overland flow, especially if the land has been cleared for agriculture.

Clearance for agriculture can affect basin runoff rates and basin response to precipitation in a number of ways. If water is a limiting factor, as it is in most parts of Alberta, then the replacement of trees by cultivated crops will usually result in more water being made available for surplus flow. Surface detention storage especially in the spring when it is most commonly needed will be much less efficient. Shade from the sun will no longer be so good so the rate of snowmelt will be accelerated. Infiltration rates particularly through constant cropping or fallow or heavy grazing may be sharply reduced, and soil structure is often adversely affected from the water absorption point of view. The runoff portion of the water balance will therefore increase due to all of these factors, especially if grain crops are grown, and the opportunities for accelerated erosion on sloping land will be intensified. The soil surface will dry out earlier in the year than is the case in a forested area but the drying out is a function of the lessened surface detention storage and the water thus lost can lead to an increased deficit in the summer period.

The problems resulting from land clearance will be dealt with in greater detail in the following chapter. However, these points illustrate the fact that water balance patterns can vary greatly between a basin in its untouched condition and the same basin after it has been opened up for agricultural use. Detailed records for either condition have not been made in Alberta as yet but some approximations to the various facets of

the water balance can be made by processing climatic data according to Thornthwaite's procedures and so deriving actual evapotranspiration, surplus, and deficit patterns for various soil moisture storage values. The soil moisture storage values reflect basin characteristics such as vegetative cover, soil texture and root depth, but not topography or slopes.

c) The water balance equation, potential evapotranspiration and actual evapotranspiration

The water balance equation--

Precipitation = (Potential Evapotranspiration - Deficit) + Streamflow $\pm$ Storage Change

has been found to be an invaluable guide in gaining a better understanding of conditions and problems in an area.

Some form of precipitation record, however inadequate, is available for most parts of the world but the measurement of potential evapotranspiration (P.E.) has always presented difficulties. It represents the amount of water that would be evaporated and transpired from a ground cover if sufficient water were available at all seasons for the process to continue at the optimum rate. In addition to requiring an abundant supply of water P.E. is also influenced by temperature, vapour pressure gradients, wind velocity, barometric pressure, and to some degree by the orientation of slopes. The complexity of the factors involved, the relative recency of the concept, and the difficulty of obtaining representative site conditions have led to the development of empirical procedures which are now more widely used than measurements taken from evapotranspirimeters which are relatively few in number and often

doubtful in accuracy. Procedures based on a few climatic parameters, available over long periods of time, checked over large sections of the world for accuracy, and reduced to tabular and/or nomogram form for ease of calculation, have distinct advantages over more complicated methods. Consequently, Thornthwaite's procedures as developed in 1948 are used in this study.[4] Methods for finding P. E. developed by Penman, Turc, Budyko and others require detailed measurements of parameters unobtainable for most stations. An added degree of refinement is possible for more tedious computational labour but when data have to be transferred from a meteorological station sixty miles away this refinement would in any case be obscured by changes caused by local conditions.

In the Thornthwaite method if precipitation and soil moisture storage capacities for the various combinations of soil texture and vegetative cover are known then actual evapotranspiration (E. T.) can be found by using bookkeeping procedures.[5, 6] Often P. E. and E. T. are different

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[4]C. W. Thornthwaite. "An Approach Toward a Rational Classification of Climate," Geographical Review, Vol. 38, 1948, pp. 55-94.

[5]A more detailed discussion of the application of this procedure to water balance patterns can be obtained from the reference previously cited and also from C. W. Thornthwaite and J. R. Mather, "Instructions and Tables for Computing Potential Evapotranspiration and the Water Balance." Publications in Climatology Vol. X, No. 3, 1957, pp. 185-195.

[6]In this thesis soil moisture storage capacity is taken as the amount of available moisture stored in a soil of a particular texture, and within the root zone of the particular vegetative cover being discussed. It is composed mainly of retention storage held between field capacity and wilting point. In a clayey soil where percolation to depth is slow some water in detention storage may also be used by plants.

if moisture is a limiting factor, so this can result in a deficit which may vary greatly from year to year. In addition, precipitation falls in the winter when P. E. is very low so there may also be a surplus present in the same year as a deficit but at a different season. This surplus becomes available for streamflow.

Computations of this type can give some insight into water balance patterns in an area. However it must be understood that they are purely empirical. They are less adequate than one might wish but for the Spring Creek basin they constitute the only available means at the moment of evaluating water needs, water yields, and their seasonal and annual distributions.

Monthly and annual potential evapotranspiration patterns are indicated in Figures 9 and 10 which have been compiled from Grande Prairie temperature records. These can be transferred to most parts of the Spring Creek basin without any great alteration in amount. It should be noticed that both annual and monthly P. E. patterns show much less variation than do the precipitation patterns (Figures 6 and 7). The degree of deviation from the norm in any one month in summer is seldom more than one inch, but greater differences exist at the beginning and end of the season both in P. E. amount and in the actual times of commencement and completion.

Water is nearly always in short supply during some part of the summer in the Peace River area so actual evapotranspiration does not often equal potential evapotranspiration especially for many of the lower soil moisture storage values.

Soil moisture storage is a rather complex factor dependent

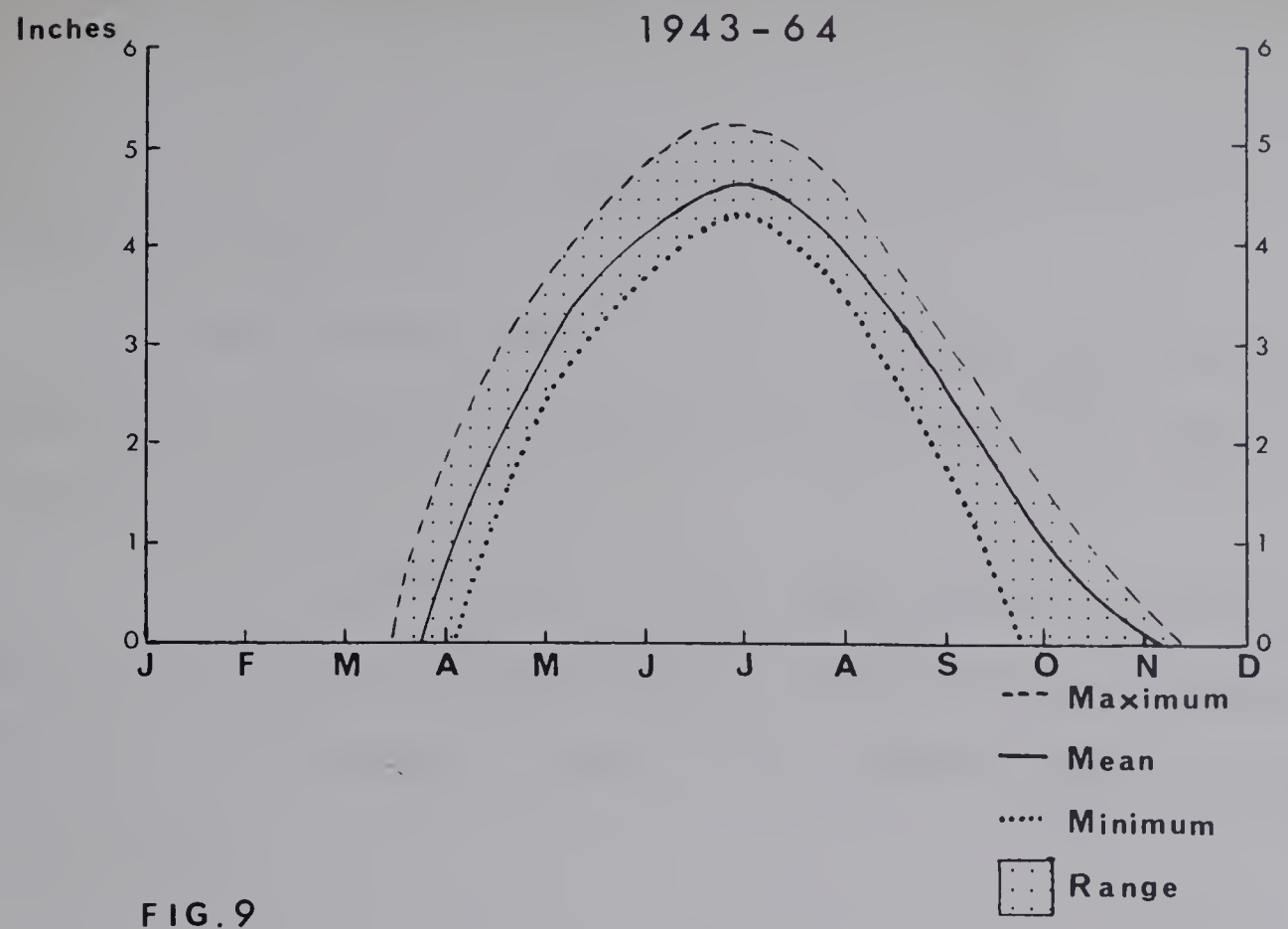


FIG. 9

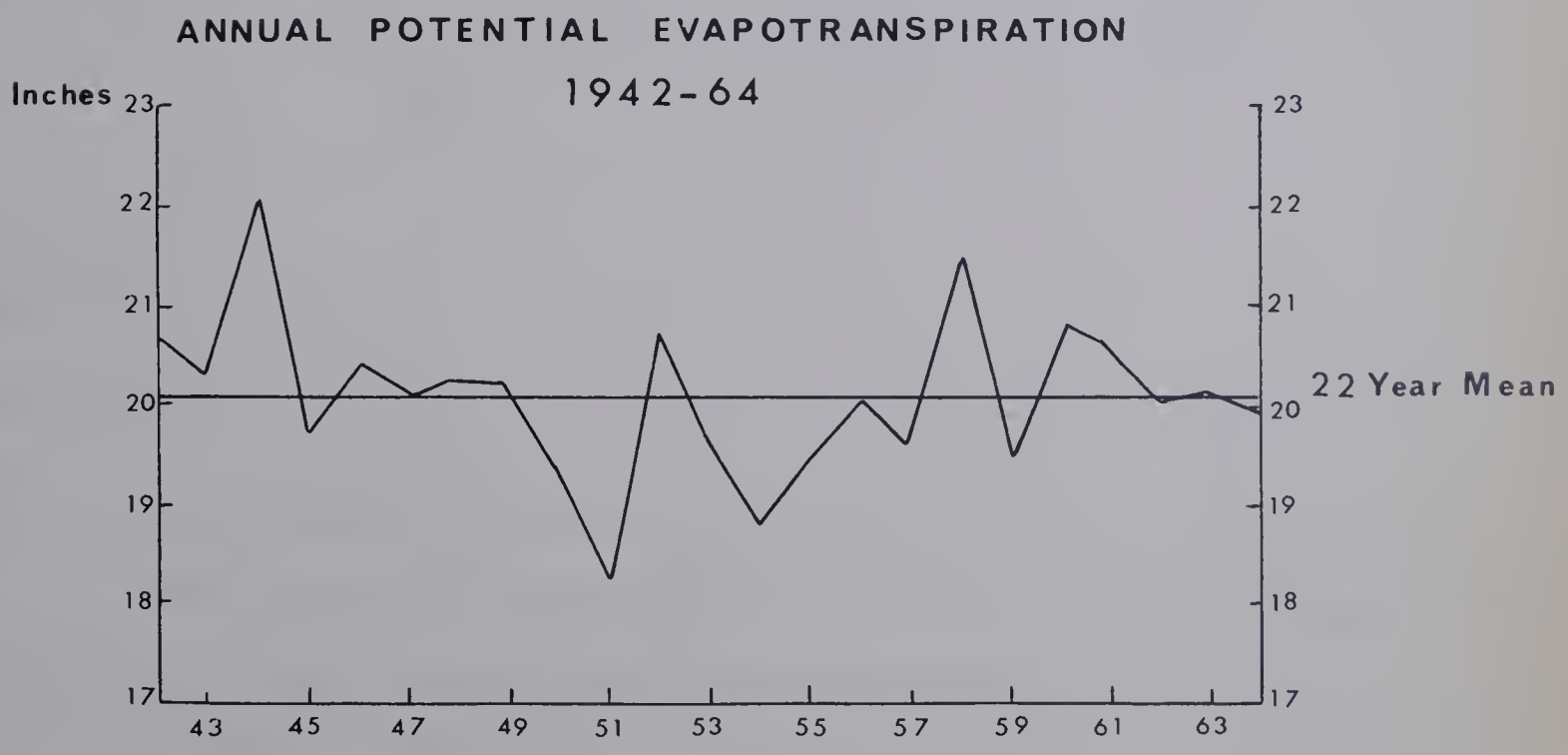


FIG. 10

Compiled from Dept. of Transport Monthly Meteorological Reports 1942-64 for Grande Prairie

upon the soil, the type of vegetation, and the age of the vegetation. A fine-textured soil, for instance a clay, has a higher soil moisture storage capacity for the same depth than has a coarse-textured soil such as a sand or a sandy loam.

The rooting system's depth and density depend on the type of vegetation - the deeper and denser the root network the more water is available to the plant for growth.

It has been assumed in this study that in the Spring Creek basin soil moisture storage capacities for the various combinations of soil texture and vegetative cover will approximate the values suggested in Table III.

TABLE III

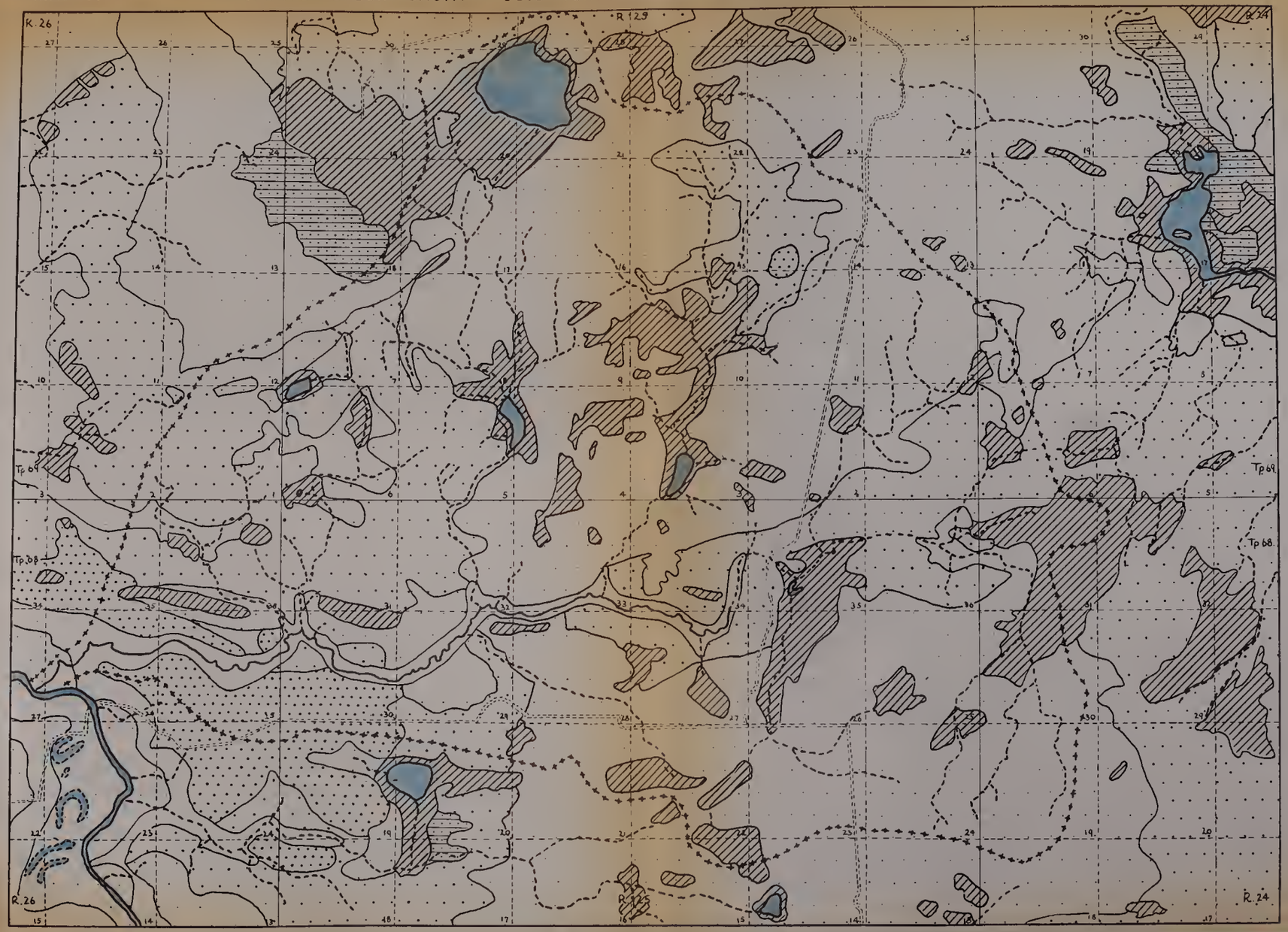
PROVISIONAL SOIL MOISTURE CAPACITIES WITH DIFFERENT COMBINATIONS OF SOIL AND VEGETATION

Soil Textures	Cereal Grains	Forage Crops, Pasture	Forest
Sand	1"	2"	6"
Sandy loam	2"	4"	8"
Loam and silt loam	4"	8"	12"
Clay loam	4"	8"	12 !"
Clay	4"	8"	10"

This Table has been adapted from one proposed by Thornthwaite and Mather, [7] with some allowance attempted for the lack of mature tree

[7] C. W. Thornthwaite and J. R. Mather, op. cit., p. 244.

MAP 8. SPRING CREEK BASIN – SOIL TEXTURE FOR WATER BALANCE ESTIMATION PURPOSES



KEY

- SAND
- SANDY LOAM
- LOAM AND CLAY LOAM
- CLAY
- ORGANIC SOILS
- TEXTURE VARIABLE AND GENERALLY UNCLASSIFIABLE

Base Map – Topographical Sheet 83K/13, D.M.T.S., 1960.

the amount of sand present and the percentage of stones in the Braeburn. The large area of Bb. Do. Co. (stony phase) soils in the north - central part of the basin has been classified as in the loam to clay loam category but in actual fact the soil moisture storage is probably lower than it is with most soils in this group but is still too high to be classified with sandy loam.

The categories portrayed have been governed by the data available but the combined use of the map for the most suitable textural class and the table for the most suitable vegetative cover should give realistic values of the most appropriate soil moisture storage capacity to use for any particular purpose. It must be emphasised again that these are provisional proposals. No measurements of any type have so far been made within the basin. These values, drawn mainly from other regions and tentatively adapted for use in the Spring Creek area, constitute a starting point from which more detailed studies can later be conducted.

The concept and measurement of P. E. has been covered in some detail, the various other elements of the water balance equation have been touched upon, and soil moisture storage values used in the calculations have been explained. It is now possible to examine the water balance picture for the basin for particular years. The records used are again derived from Grande Prairie and the extra precipitation in the Spring Creek basin may result in a rather larger surplus and possibly a smaller deficit than portrayed here but allowance for these cannot properly be made for such a heterogeneous area without local

measurements.[8] The broad patterns are suggested and this in itself can be extremely helpful in understanding the various implications of the water balance developed in more detail later in this chapter and in the one following.

A diagrammatic representation of the water balance for particular years for a four inch storage capacity can be seen in Figures 11 to 14. This would include cereals grown on loam, clay loam, or clay, and also alfalfa and new forest regrowth (less than thirty feet high) on sandy loam, a common soil textural class in the basin.

A surplus and a deficit are both present in Figure 11, the 22-year average graph.[9] A substantial deficit occurs during the summer months when P. E. rates are higher than the available moisture supply. Recharge of soil moisture storage takes place, partly before winter sets in and afterwards from the snowmelt in the spring. The recharge usually consumes all the precipitation which has fallen up to late January and the extra three inches (water equivalent) of snow which falls after this date forms the annual surplus. In April or May the temperature rises above freezing point and monthly P. E. totals soon overtake precipitation. For a time, however, any excess water required over and above the precipitation that has fallen can be met from soil moisture reserves so there is no deficit until this additional supply is exhausted. From mid-June onwards usually only the summer precipitation is available to the plant. If this is markedly deficient then crop yields can suffer.

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[8] See Appendix VI.

[9] Constructed from the water balance equations for each of the 22 years.

In the wetter than average year (1948) precipitation was above normal in both summer and winter so the surplus was large and the deficit small. In July the rainfall was actually greater than the potential evapotranspiration so the slight excess contributed to a partial replenishment of the soil moisture supplies which had been expended.

It occasionally happens that heavy summer rainfall is sufficient to refill soil moisture storage completely and still leave an excess for summer runoff. This happened in 1964 but it is rather uncommon. What may occur, however, is that severe summer storms may have short duration intensities in excess of infiltration capacities and runoff can take place under these conditions, especially from crop and summerfallow land which have lower infiltration rates than land under forest or grass. Some of the most severe erosion that the Peace River area has suffered is a product of these high intensity summer storms, a good example being the heavy rains which fell in late June of 1965 (See photos 16, 17 and 21).

Figure 13 is an illustration of the water balance in 1945 which was a drier than average year. Winter precipitation was adequate so a two inch surplus occurred. Early summer precipitation was fairly close to normal but drought conditions prevailed in July and August. The crop yield was therefore below normal. This was also true for 1963 which had the lowest summer precipitation in the period of record (Figure 7) and the average wheat yield for the whole of Census Division 15 was only 10.4 bushels per acre.[9]

In the close to average year (1947) the normal precipitation trend, with a summer maximum and spring and autumn minima, is shown but in

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[9]See Appendix VII.

an exaggerated form. The summer deficit is quite close to the average amount, about five inches, but the surplus is more like that in Figure 12. In a 22-year period it is unlikely that a perfect "average" year for a complex of factors will occur so 1947 represents a best fit choice where the P.E., E.T., and deficit all fitted the norm much better than did the surplus.

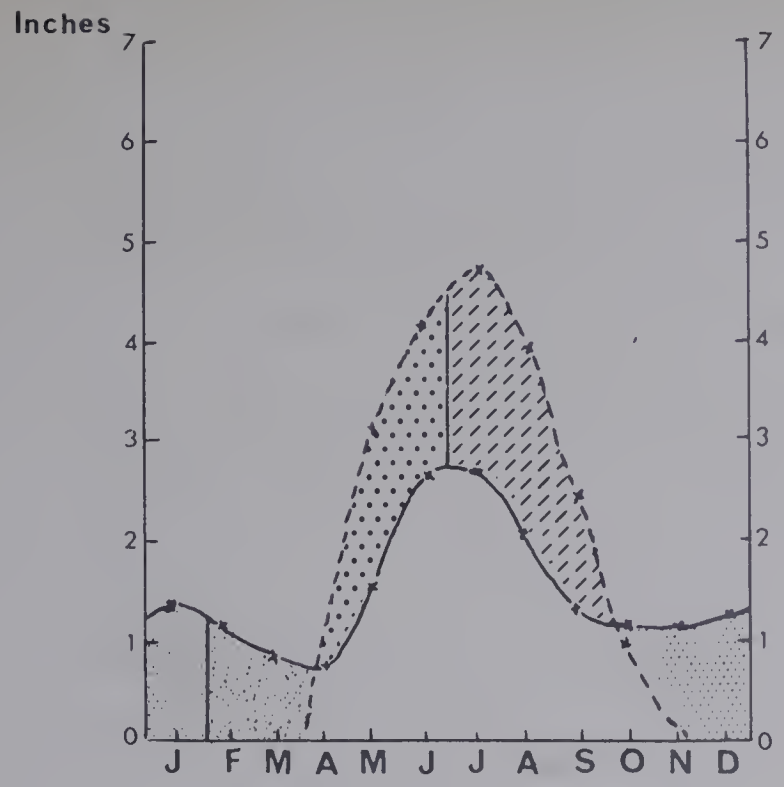
Some indications of the water balance picture for the basin are presented in these diagrams but only for a restricted range of ground conditions. The tables in Appendix IV have been computed to show the water balance equations for each of seven different soil moisture storage values. In this way, it should be possible to find a suitable table for almost any range of soil and vegetative cover combinations likely to be present within the basin either now or in the future. Thornthwaite's procedures for evaluating the water balance work quite well in the prairies--it is the choosing of appropriate soil moisture storage capacities that perhaps presents the greatest difficulty.

d) Soil Moisture Retention Patterns

When water balance patterns are being computed the bookkeeping procedures necessary to obtain monthly surplus and deficit patterns entail the calculation of the soil moisture present within the soil at the end of each month. Soil moisture retained after the end of the snowmelt period is an important control in influencing water use patterns by cultivated and wild vegetation during the summer months. It also affects any later surplus that may occur i.e. if the soil moisture level is high in summer then only a slight addition is needed to fill the soil to field capacity and cause a surplus to result from above average precipitation. The

ANNUAL WATER BALANCE PATTERNS - 4" STORAGE

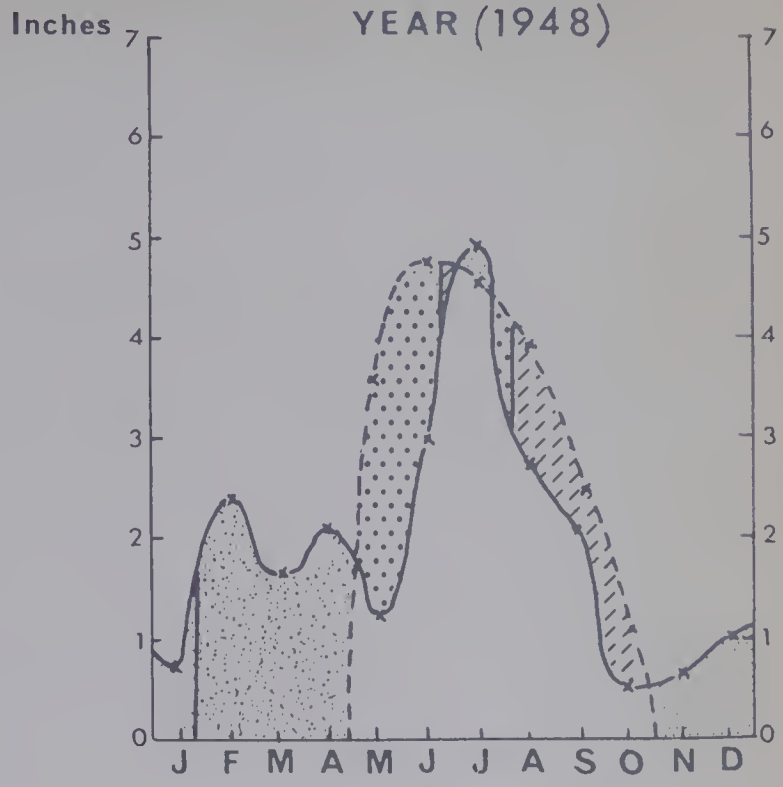
THE 22 YEAR AVERAGE



17·83 = (20·06 – 5·16) + 2·93 ±0

FIG. 11

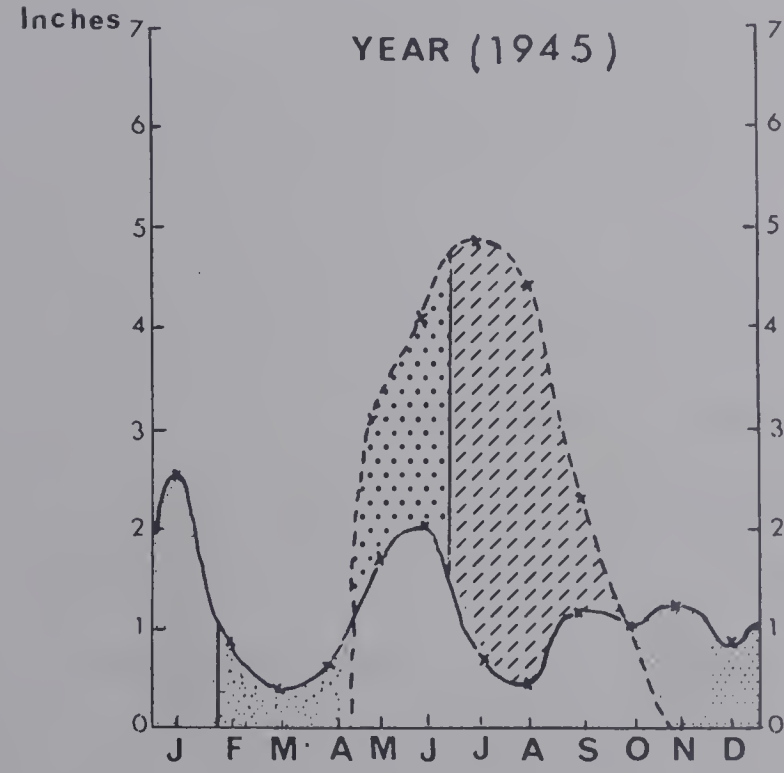
WETTER THAN AVERAGE YEAR (1948)



22·29 = (20·25 – 2·17) + 5·26 – 1·05

FIG. 12

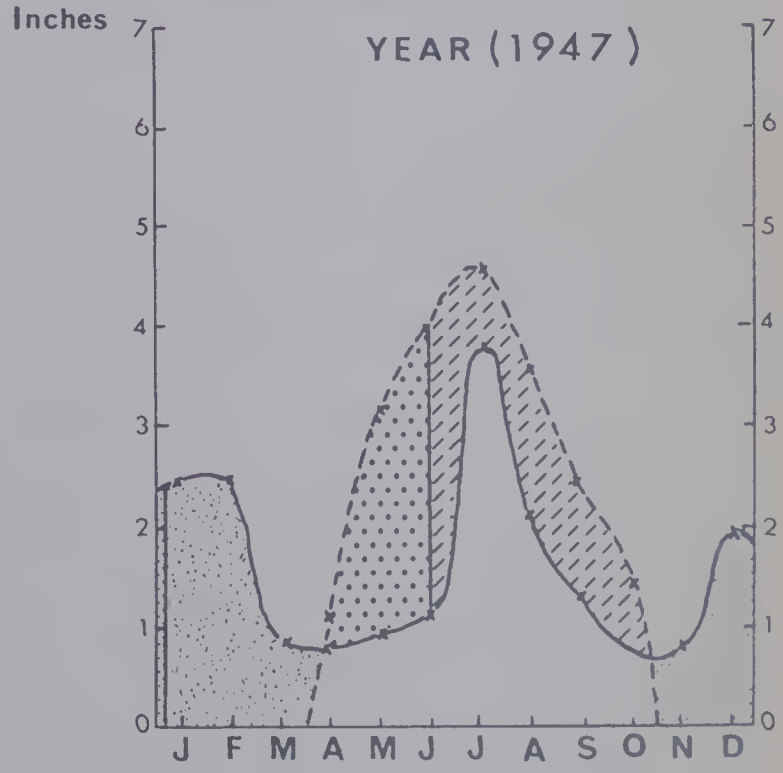
DRIER THAN AVERAGE YEAR (1945)



13·25 = (19·73 – 8·81) + 2·18 + 0·15

FIG. 13

CLOSE TO AVERAGE YEAR (1947)



19·03 = (20·12 – 5·52) + 5·18 – 0·75

FIG. 14

---- Potential Evapotranspiration

Water Surplus

Water Deficiency

—— Precipitation

Soil Moisture Utilisation

Soil Moisture Recharge

Compiled from Dept. of Transport Monthly Meteorological Reports 1942 - 64 for Grande Prairie, and computed according to Thornthwaite's procedures as

amount of soil moisture may also be taken into account by farmers practising summerfallow since the advantages of this for weed control or moisture accumulation are often rather questionable in a year when full recharge has taken place.

The soil moisture retained in the soil at the end of April, May, July, and October is tabulated in Table IV for the 22-year period for four of the commonest storage values. It should not be assumed that because the calculations have been done to the nearest tenth of an inch that the values obtained are accurate to this degree. No cross-checks are available so the theoretical volumes could vary from the actual volumes by half an inch or more, particularly with the spring estimates for the eight and twelve inch storage capacities.

It can be seen that in nearly all years the maximum amount of water present in the soil for these four months is at the end of April. The snowmelt runoff is either in progress by then or it is complete as far as the upper layers of the soil are concerned. Potential evapotranspiration may already exceed precipitation but in general the soil moisture reserves have only been slightly depleted and in no case is it already exhausted.[10] In May P.E. tends to draw even further ahead of precipitation so reserves are further reduced - eleven years out of the twenty-two have no soil moisture left for the two inch shortage so from then onwards in these years plant growth will have to rely on summer precipitation alone. The four inch soil moisture storage capacity was

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[10] This is not true for the one inch soil moisture storage capacity. It was already exhausted in April in 1944, 1946 and 1960.

only exhausted once in May during the period of record (1944) so in loam or clay loam soils cereal grains, for example, can receive a better start to their period of growth than in a sandy soil where deficiencies can often already be felt.

July is one of the driest months as far as soil moisture reserves are concerned. The median value, which in these tables is a truer reflection of the most common state of affairs than is the mean, is zero for both two and four inches storage values and it is only 0.7 of an inch for eight inch storage. However, July is one of the months when rainfall is at its most unpredictable (Figure 6) so there are years when precipitation does exceed P.E. and some addition is made to soil moisture.[11]

A forage crop cover, especially a mixture that contains the deep rooted legume alfalfa, would seem less likely to suffer from water deficiency over all the soils of the basin. On the loam and clay loam soils there is water still present in the soil at the end of July to supplement the precipitation. Even on sandy soils where deficiencies are most likely the denser cover promotes more efficient infiltration and surface detention storage than is the case with a cereal crop.[12]

In October a deficit is still quite common. Soil moisture reserves have recovered only slightly despite the downward trend of P.E. By this time of the year, however, any deficit is not usually of great importance since the crops have either been cut or are waiting to be cut and the

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[11] The most obvious examples are 1948, 1955, 1956, and 1964.

[12] A deep rooted legume cover can also help to open up any clay substratum in Codesa areas.

growth cycle has been completed. The amount of water added to the soil from a cultivated area is therefore rather more than is suggested by the table. Evaporation does take place but transpiration losses are low because of harvesting operations. This is the month in which soil moisture recharge begins, either in the form of rain which percolates into the soil or as potential recharge in the form of snow which accumulates on top, depending on the temperature.

The values for the twelve inch storage capacity represent the water which can be held in the root zone of a mature or almost mature forest in the Spring Creek area if it is growing on a loam or clay loam soil. It can be deduced from the table that complete recharge to the full twelve inch level did not take place in any year of the period of record,[13] although in 1952 it came very close since 11.3 inches of water were in the soil early in the month but the total dropped to 10.7 inches at the end (See Appendix V).

Despite this lack of complete recharge and the consequent small amount of runoff,[14] moisture is present throughout most of the summer. The values shown in Appendix V would suggest that it is usually August before the trees have to rely on precipitation sources alone. In actual fact since the rate of withdrawal becomes slower as the wilting point is approached small amounts of soil moisture will be available some time after this date. Younger trees or trees in more

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[13] It actually did take place in 1965. The heavy summer rains of 1964 meant that over seven inches of water were already present in the soil before winter came so this was later added to in the form of snow and the first general, rather than local, surplus occurred in this category for many years.

[14] Local concentration due to snow blowing may give a surplus in all years from a limited area but only at the expense of adjoining areas.

TABLE IV

MOISTURE RETAINED IN THE SOIL AT THE END OF THE STATED MONTHS

	2 inch storage				4 inch storage			
Year	April	May	July	October	April	May	July	October
1943	0.4	0.4	0	0.7	2.4	2.4	0	0.7
1944	0.7	0	0	0	2.0	0	0	0
1945	2.0	0.6	0	0	4.0	2.6	0	0
1946	0.9	0	0	0	2.9	1.1	0	0
1947	1.7	0	0	0	3.7	1.5	0	0
1948	2.0	0	0.3	0	4.0	1.7	0.3	0
1949	1.3	0	0	0.1	3.3	1.6	0	0.1
1950	2.0	1.0	0	0.1	4.0	3.0	0	0.1
1951	2.0	0.9	0	2.7	4.0	2.9	1.7	2.7
1952	1.4	0	0	0	3.4	1.1	0	0
1953	2.0	1.3	0	0	4.0	3.3	1.4	0
1954	2.0	1.2	0	0	4.0	3.7	0	0
1955	2.0	1.8	1.3	1.0	3.6	3.4	1.3	1.0
1956	1.7	0	0	0.5	3.7	0.4	1.0	0.5
1957	1.4	0	0	3.6	3.4	1.3	0	3.6
1958	1.1	0	0	1.3	3.1	0.3	0	1.3
1959	2.0	0.5	0	1.4	4.0	2.5	0	1.4
1960	0.6	1.0	0	0	2.6	3.0	0	0
1961	1.8	0	0	0.6	3.8	2.0	0.4	0.6
1962	2.0	1.0	0	0	4.0	3.0	0.1	0
1963	2.0	0	0	0	4.0	1.9	0	0
1964	1.7	0.9	2.0	1.1	3.7	2.9	4.0	3.1
Total	34.7	10.6	3.6	13.1	77.6	45.6	10.2	15.1
Average	1.6	0.5	0.2	0.6	3.5	2.1	0.5	0.7
Median	1.75	0.2	0.0	0.05	3.7	2.2	0.0	0.05

TABLE IV (Continued)

	8 inch storage				12 inch storage			
Year	April	May	July	October	April	May	July	October
1943	4.5	4.6	0.4	0.7	4.5	4.6	0.4	0.7
1944	2.0	0	0	0	2.0	0	0	0
1945	6.2	4.8	0	0	6.2	4.8	0	0
1946	3.2	1.4	0	0	3.2	1.4	0	0
1947	7.7	5.5	1.8	0	8.9	6.7	3.0	0
1948	8.0	5.7	4.1	1.8	9.3	6.9	5.4	3.1
1949	6.3	4.6	0	0.1	7.6	5.9	0.1	0.1
1950	6.7	5.7	0.3	0.1	6.7	5.7	0.3	0.1
1951	7.3	6.2	5.1	4.2	7.3	6.2	5.1	4.2
1952	7.4	5.1	0.8	0	10.7	8.4	4.1	0.8
1953	5.7	5.0	3.1	0	6.5	5.8	3.9	0
1954	6.9	6.0	2.3	0.4	6.9	6.1	2.3	0.4
1955	4.0	3.8	1.3	1.0	4.0	3.8	1.3	1.0
1956	7.4	4.1	1.9	0.5	7.4	4.1	1.9	0.5
1957	5.1	3.0	0.3	3.6	5.1	3.0	0.3	3.6
1958	7.1	4.3	0	1.3	9.3	6.6	2.0	1.5
1959	7.4	5.8	0	1.4	7.5	6.0	0	1.4
1960	4.1	4.6	2.3	0	4.1	4.6	2.3	0
1961	4.0	2.2	0.6	0.6	4.0	2.2	0.6	0.6
1962	6.6	5.6	2.7	0	6.6	5.6	2.7	0
1963	8.0	5.9	0	0	9.3	7.2	0.1	0
1964	5.3	4.5	7.7	7.1	5.3	4.5	7.7	7.1
Total	130.9	98.4	34.7	22.8	142.4	110.1	43.5	25.1
Average	6.0	4.5	1.6	1.0	6.5	5.0	2.0	1.1
Median	6.45	4.7	0.7	0.25	6.65	5.65	1.6	0.45

Source: Monthly Meteorological Records for Grande Prairie (1943-64) which have been processed according to Thornthwaite's methods as published in 1948.

sandy areas experience a water shortage earlier in the year so their growth may be more intermittent and less vigorous, and the density of the vegetation is often reduced as the older or healthier plants are more successful in competing for water (see photo 13).

Space limitations preclude the incorporation of moisture retention tables for all the months within the body of the thesis. Conditions in June, August, and September can only be guessed from the values shown in the table but more detailed records for all months and all storage values are plotted for the 22-year period in Appendix V. It sometimes happens that the months chosen paint a rather deceptive picture, for instance 1944 appears to have been an inordinately severe year for any type of plant growth since the moisture in the soil at the beginning of the year was so low. In actual fact, the precipitation in June and September exceeded P. E. so conditions were not so poor as in 1945 and 1946 when the summer precipitation in each case was very much less (see Figure 7). The year 1946 was the driest on record and a rather poor recharge (only up to the four inch level at the end of March) was combined with a very dry summer to give conditions in which wind erosion may be severe, especially in fallowed areas.

The advantages of a soil/crop combination with the greatest possible water capacity in its root zone are clearly illustrated if uninterrupted growth is to proceed throughout the season at or near optimum levels.

e) Deficit and Surplus Patterns

The deficit is the difference between potential and actual evapotranspiration. Potential evapotranspiration is not significantly

affected by soil type or vegetative cover but whenever P. E. exceeds precipitation the actual evapotranspiration can be strongly influenced by local soil and plant conditions. The actual evapotranspiration for all the years for all seven different storage values can be seen in Figure 15 which is derived from the water balance equations in Appendix IV. Only in a few cases are P. E. and E. T. equal,[15] and in all of these years except 1964 only two or at the most, three of the upper storage capacities were affected. In all other cases therefore a deficit occurred at some time during the summer.

Actual evapotranspiration in some ways can be looked upon as an index of the suitability of an area or a particular year for plant growth. The more evapotranspiration that takes place the more likelihood there is of a favorable yield, other conditions being equal. The occurrence of deficits is one way in which growth can be impeded and the magnitude of the deficits which were experienced in the 22-year period is plotted on Figure 16. The deficits are relatively high for the lower storage values with an average deficit of eight inches for cereals in a sandy area (say Section 1, Tp. 69, R. 25, or section 30, Tp. 68, R. 25), and seven inches for any vegetation which has a two inch moisture storage capacity on a particular soil (alfalfa on sand, or cereals on sandy loam). Alfalfa, or some other deeply rooted forage crop, would experience an average deficit of five inches on a sandy loam and this for a relatively mature forest stand would be as low as three inches. On a clay loam soil the deficit under forest would be about half an inch less.

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[15] P. E. and E. T. were equal in 1948, 1951, 1952, 1954, 1958 and 1964.

ACTUAL EVAPOTRANSPIRATION FOR DIFFERENT SOIL MOISTURE STORAGE VALUES

1943 - 64

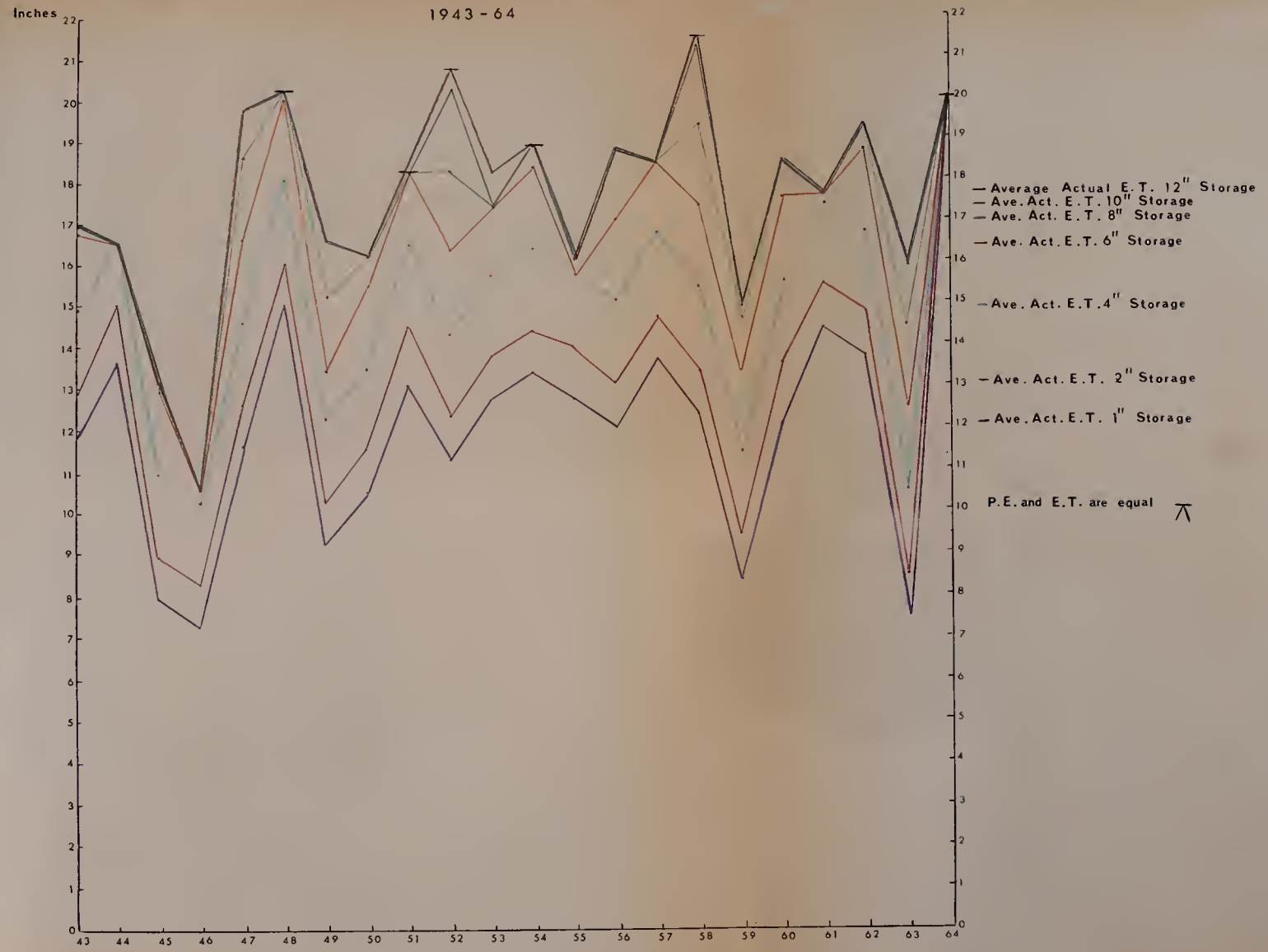


FIG. 15

Compiled from Dept. of Transport Monthly Meteorological Reports for Grande Prairie 1943-64 and computed according to Thornthwaite's procedures (1948)

The average values, however, should not be overstressed because of the great variation from year to year. For a two inch storage capacity the deficit can vary from a maximum of over twelve inches to zero in 1964. This illustrates the element of risk involved in cultivating a soil of this type. Crops of grain can be produced in all years. The return can be quite high in many cases but in others it will barely be enough to show a profit. There are many other variables that are important, such as the timing and duration of the drought but the profits from grain farming especially on an average Peace River size of farm tend to be very low when the deficit exceeds eight to ten inches.[16] Alfalfa or some other leguminous crop would be a wiser and more profitable choice under these conditions, both for crop yield and erosion control.

It was shown earlier (Table IV) that recharge to the full twelve inch level never took place in the 22-year period and this is almost the case for the ten inch storage capacity.[17] The deficit for these values is therefore quite close to the eight inch storage deficit. Forest on loam, clay loam or clay has no particular growth advantage over forest on sandy loam, or indeed over forage crops on loam or clay loam. A deeper rooting system is of no value past this point since there is not enough moisture in the soil for it to utilize.

The degree of variability of the deficit is primarily a reflection of the erratic summer rainfall. Potential evapotranspiration varies

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[16] A. H. Laycock, Water Deficiency Patterns in the Prairie Provinces. Prairie Provinces Water Board, Report No. 8, 1964, p. 17.

[17] Complete recharge occurred only in 1952 and 1958.

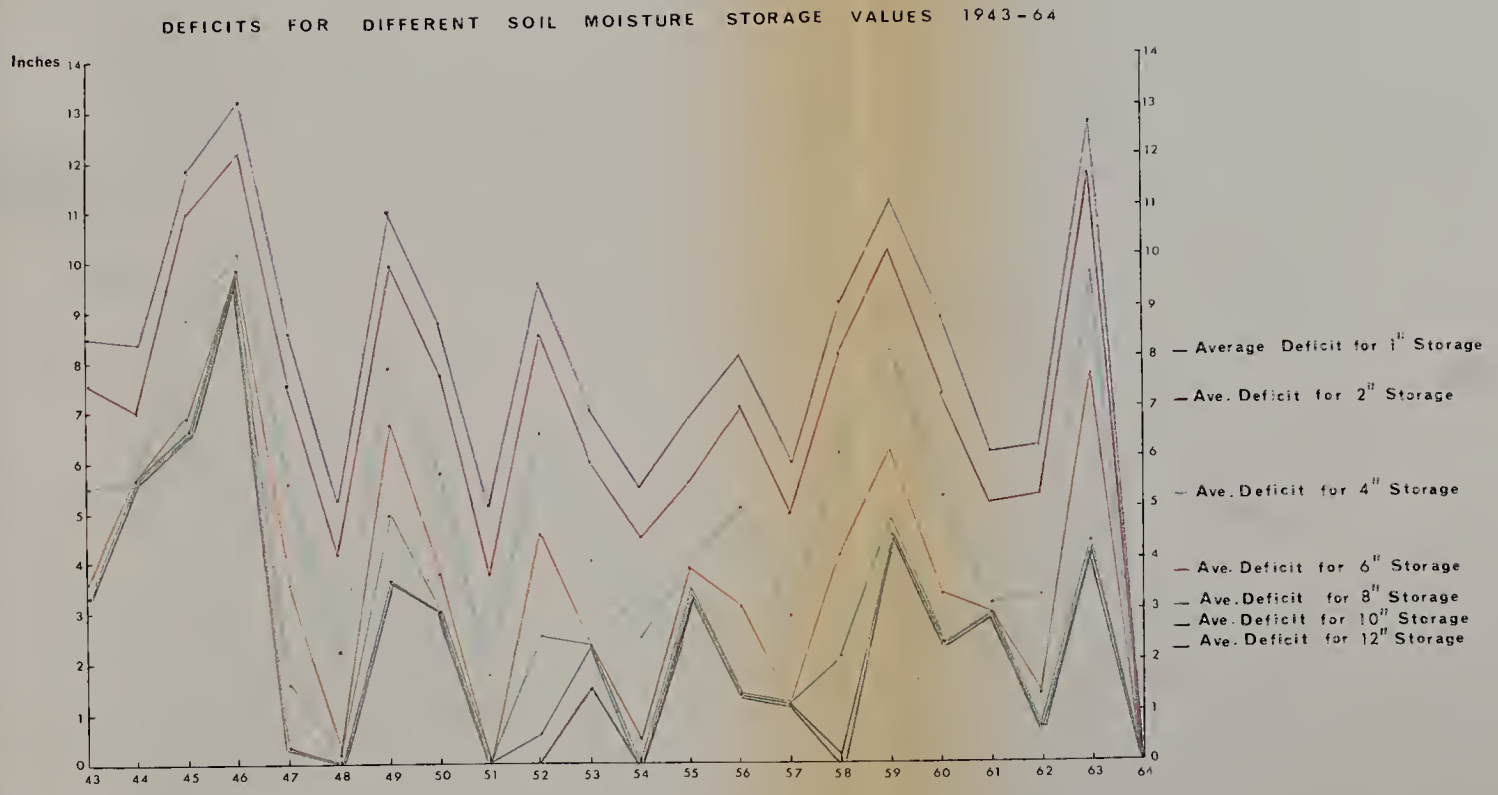


FIG. 16

Compiled from Dept. of Transport Monthly Meteorological Reports for Grande Prairie 1942-64 and computed according to Thornthwaite's procedures 1948

with the temperature but when water is limiting the actual evapotranspiration, and consequently the deficit, vary more directly with the precipitation. Surplus patterns, like the deficits, are controlled by soil moisture storage and precipitation but this time by winter and previous autumn precipitation rather than by what falls in the summer. From the precipitation diagrams (Figures 6 and 7) it can be seen that an average of about seven inches falls during a period when evapotranspiration is almost negligible.[18] Once the soil moisture storage has been built up to its maximum capacity again in the spring any excess becomes available for the annual surplus either in the form of surface runoff or groundwater recharge. As mentioned earlier there is little chance of summer surpluses, especially under deep-rooted forest conditions, unless precipitation intensities exceed infiltration capacities.

The greatest proportion of the annual surplus occurs therefore in the spring, most commonly in April but in five years out of the total twenty two at least part of the thaw was delayed until May since the mean monthly temperature for April was below 32°F. When the thaw comes the soil, especially in forested regions, is seldom frozen into such an impermeable mass that water cannot pass into it from above.[19] If soil moisture storage is low, say two inches, it will soon be replenished and a large surplus may result. Conversely, if the

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[18] Except on days when the temperature rises above 32°F. See Appendix VI.

[19] Concrete ice in lacustrine plain sediments may be an exception. This would mainly apply to the small area of lacustro-till on the north western margin of the basin.

moisture capacity in the root zone is high little or no surplus will be present, assuming substantial depletion in the previous year.

Surplus patterns for the chosen soil moisture storage values are plotted on Figure 17 for each year for which climatic data are available. There was no surplus for any year in the twelve inch storage category, except in 1965 for which complete records have not yet been published. Only two years had surpluses for the ten inch storage rate, five years had surpluses for eight inch storage, fifteen for six inch, twenty for four inch and twenty two for two inch. At the present time with the basin in a forested state the most common storage rates, if Table III is found to be valid, will be the four inch, the eight inch, and the twelve inch. In cultivated areas in the future there will probably be a downwards shift mainly to two, four, and eight inch soil moisture storage capacities.

A large number of years have had no surpluses for high storage values so median values are included in the text in addition to the mean values at the side of the graph. For storage values above six inches only the exceptional years provided a surplus so the average, i. e. the one which is most likely to occur, is zero. In the very sandy forested areas, where a six inch storage capacity is likely, a surplus is present in most years, the median value being 0.8 inches. The three lower storage rates (one, two and four inch soil moisture capacities) have means and medians agreeing to within a tenth of an inch so the values for the means are less distorted. Only the immature forest under thirty feet in height would enter into these categories at the

moment,[20] so although substantial surpluses can be produced under this type of forest the area involved is not so great as the future area which will be within these storage capacities once land is cleared for agriculture.

As clearing proceeds land once under forest, say with an eight or twelve inch storage capacity, is likely to be replaced by cereals with a two or four inch moisture storage capacity within its root zone, or by forage crops with four or eight inch storage (Table III). A change from eight inch to two inch storage could cause a surplus to rise from zero to an average of almost five inches since shallower rooted vegetation cannot tap the water below its root zone and so it is not "lost" through evapotranspiration. This may be an extreme case to take but a drop from eight inch to four inch storage within the root zone of the plant can still change the average surplus from zero to nearly three inches.

Runoff does take place from these theoretically zero surplus forested areas because of local snow-blowing surpluses as mentioned previously, but this is still very little compared with the surpluses likely to come from the same ground after breaking and clearing. Sloughs will tend to fill to a higher level in the spring and overflow will occur more frequently. A greater area of the basin will normally contribute to streamflow than was previously the case, and detention storage measures will have to be planned to the full to detain this surplus for as long as possible. The marshes will probably be

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[20] Not into one inch soil moisture storage capacity.

SURPLUSES FOR DIFFERENT SOIL MOISTURE STORAGE VALUES 1943 - 64

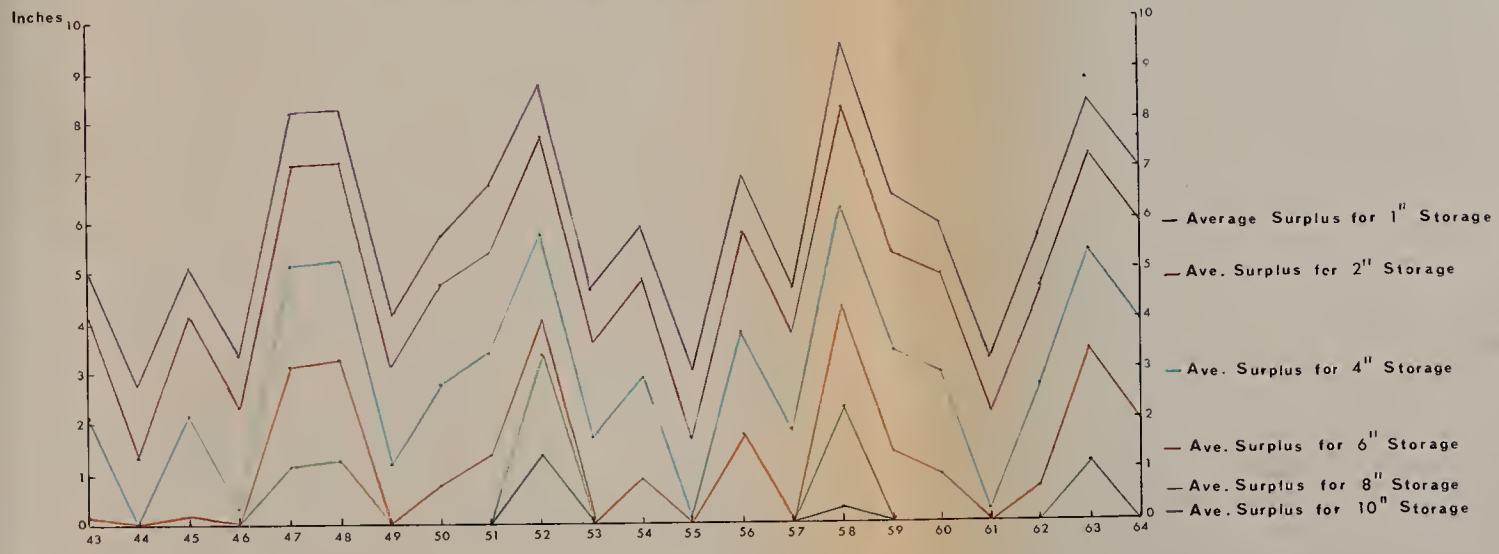


FIG. 17

Compiled from Dept. of Transport Monthly Meteorological Reports for Grande Prairie 1943 - 64 and computed according to Thornthwaite's procedures (1948)

replete from their own snowmelt and adjoining groundwater surpluses, so little in the way of detention storage can be expected from them unless some drainage is carried out. The preservation of forest along the stream courses and the steeper slopes can help to trap the snow blown off the more open fields and also to promote added infiltration of runoff that might otherwise flow through the area. However this is only one measure. Some action will have to be taken at the point of fall to detain any surplus for the maximum possible time. It may not be used in plant growth if the soil cannot retain it, but stubble mulch tillage or a grass cover or contour furrows can deter overland flow to a considerable degree so that the major contribution to streamflow can be a groundwater rather than a surface one. If a less permeable layer is present at some depth especially in Codesa soils, it may be possible for deep-rooted forage crops, forest growth, or dugouts to intercept this water on its way to the streams since its passage may be more in the form of interflow rather than groundwater.

Groundwater supplies, because of surplus amounts in the past and probably also in the future, should provide a reliable water resource for domestic use through wells in addition to its contribution to streamflow. Gravel lenses and other coarse materials seem to be quite common in the till according to seismic shot-hole reports. Shallow wells may also be dug to intercept water on its way to the stream or to a local slough which can often be a groundwater evaporation basin as well as a surface runoff storage reservoir.[21] The presence of phreatophytic

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[21] These are not always the most satisfactory wells since their location and the nature of their construction often permits pollution. J. F.

willow growth in areas such as sections 30 of Tp. 68, R. 25 and 13 of Tp. 69, R. 25 and also in several other areas of Codner or Goose soils probably means that these plants are tapping some supplemental water source. Local precipitation alone is not sufficient to support their growth.

Some parts of the basin, for instance along the eastern margin, have a more homogeneous clay till composition at depth.[22] Groundwater at shallow depths may not be so easy to find here. The southeastern corner, however, does have some sandstone layers below the clay but drilling here and elsewhere within the basin would be necessary to explore their water-bearing characteristics. No information is available on local bedrock aquifers at the moment. The Edmonton formation which is most likely to be present is mainly of continental or freshwater origin so the water quality should be quite favourable.[23]

The contribution of the surplus portion of the water balance can be tapped for farm use by other means as well as through groundwater. Cereal grain production will lead to a larger surplus than will forage crops. Probably both will be grown in a complementary fashion, possibly some grains as green feed to reduce profit risks due to the short growing season. Stock-watering dams may therefore be built for the cattle on some of the streams but preferably not on Spring Creek

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Jones, Groundwater Geology of the Beaverlodge District, Alberta. Research Council of Alberta, Preliminary Report 59-2, p. 20.

[22]Obtained from a study of the seismic shot-hole map supplied by the Amerada Petroleum Corporation.

[23]In the Beaverlodge area, which is underlain by strata of the Wapiti formation (of which Edmonton rocks form a part), geologic

itself nor on its three named tributaries. Flash floods may be reduced in level by conservation techniques but the amount of flow in certain seasons could swamp the structure and the expense involved in combating this may not be worthwhile. The tertiary streams (accepting for this purpose Spring Creek as a primary) may be better suited for damming purposes. The flow is not so great but in most years enough water could be trapped for the animals and this may be supplemented from sloughs, dugouts, or wells. These streams will not be incised so deeply and the slopes down to them should not be so steep. Cattle tracks on even moderately steep slopes can cause a surprising degree of erosion on most soils (see photo 27). In addition the forest growth along the more important streams should receive the maximum amount of protection from domestic animals to avoid erosion, overgrazing, soil compaction and wildlife habitat deterioration.

The water can be used in a number of ways, described in more detail in Chapter IV. An increase in the surplus may be good for certain purposes but one of the most productive ways of utilizing water is to take advantage of it at the point of fall and return it to the atmosphere in the form of plant transpiration. Forage crops, in addition to some build-up of soil organic matter and the dense protective mat that they form, have on average a deeper rooting system that can tap greater water supplies than cereals and so they are less affected by summer water shortages, particularly if earlier recharge from snowmelt has been up to normal.

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conditions are, for the most part, favourable for the development of wells for domestic purposes at a reasonable cost. J. F. Jones, op. cit., p. 25.

f) Some tentative runoff and regime relationships

In the previous section values were computed for the surplus under different conditions of vegetative cover and soil texture. These can be applied to any part of the basin to deduce the surplus in any one year for that area. After examining all this data it is possible to provide a rough estimate of the average surplus for the whole basin and the type of streamflow regime that might exist. The evaluation has only been attempted for the period 1960 to 1964 inclusive, since comparisons can then be made with other streamflow patterns in Northern Alberta as described earlier.

If the forest vegetation was mature growth the greatest amount of land in the basin would come under the eight and twelve inch moisture storage capacities. However extensive areas of recent regrowth should still be far below this stage of development. In these cases the use of the table for pasture and forage crop values seems more suitable. A small amount of immature forest in sandy areas could have as low as two inches of moisture capable of being retained in its root zone but the percentage yield from this region will be much greater than its proportionate areal expanse. The same is also true for the other areas of immature forest. In the areas where the forest cover is older the eight and twelve inch storage rates will provide some surplus even in dry years because of local concentrations of moisture due to snow-blowing, gravity seepage, infiltration capacity reduction if there is any concrete ice in spring, or through some summer precipitation exceeding infiltration capacities. Snow blowing in very sandy areas where the poplar cover is more open can also help to increase local surpluses there.

The average surplus over these five years (1960-64) for the four inch soil moisture storage capacity was three inches and it is felt that an estimate of about 2.5 inches is quite a realistic one for the average basin surplus during this time when the factors stated in the previous paragraph are taken into account. This is only about half of the measured contribution from the West Prairie river basin but when one considers the orographic intensification caused the 1,500 feet extra elevation of the Swan Hills, combined with the amount of arable land above the gauging station and the percentage of recently burnt-over land, the 2.5 inch estimate for Spring Creek seems to be a reasonable working assumption until actual measurements are taken. It is unlikely to be a serious overestimate because in many years the whole area of the basin does not contribute to streamflow and also a part of the water which does reach the stream will be lost through river-bank phreatophytic growth. The amount of land in slope may render the percentage loss in internal drainage basins rather less than that for most minor Peace River area streams but the amount of water lost through phreatophytes must still be high.

Once parts of the basin have been cleared for agriculture and some marsh drainage has been undertaken, the possible 2.5 inch surplus reaching the streams may rise to a mean of 4.5 inches, given the same amount of precipitation.

These empirically derived values are checked to some degree against rather dubious streamflow records available for rivers flowing from areas inadequately gauged for precipitation data so they can only be viewed as very rough approximations. They have, however, been

converted to yield in acre/feet from the basin merely to provide some indication of the amounts in a more commonly used hydrologic measure. In its present forested condition the mean yield on this basis would be about 132 acre/feet per square mile and the average annual streamflow over the past five years would be 5,700 acre/feet. The projected future yield increase of over fifty percent was suggested if grain was dominant over forage crops in the crop rotation. If forage crops were widely adopted as the main cover on improved land then the increase could be much less.

Forecasts of yield are probably of the right order of magnitude, although the data available are really more suitable for noting comparative patterns within the basin than for giving accurate quantitative expressions of streamflow. It could require a number of years of data from hydrometric gauges before these values can be further refined.

Some points concerning the regime characteristics of the stream can also be made from the data processed. The snowmelt maximum in most years should occur in late April or early May giving the normal hydrograph peak in this period. A secondary peak later in the year may develop if June, July or August precipitation is excessive, since in the months of heavy precipitation it is common for the extra amounts to fall during short periods of much higher rainfall intensity. Many of the gauged streams in the Peace River area were influenced in this way by the high summer rains of 1964.

It is impossible at the moment to indicate accurately how regime patterns may vary in the future when cultivation takes place. A common

practice has been to assume that in forested regions fifty percent of any surplus runs off in the month in which it occurs, fifty percent of the remainder runs off in the following month and so on - a gradually decreasing amount unless there is additional soil moisture replenishment from precipitation.[24] From an area where the cultivation of cereal crops is dominant over other agricultural produce as much as three quarters of the flow may take place in the month in which it falls and very little is left for flow in the following months. An area devoted more to forage crop production, or to a permanent grass cover where a more fibrous sod can be built up, should probably fit in between these two positions.[25] Tentative runoff patterns based on these assumptions are indicated in Figures 18, 19 and 20 for a tree cover, a forage crop cover, and a cereal cover on the same type of soil in the basin. The year 1946 was picked as representing extremely dry conditions, 1958 as a year with a high snowmelt surplus but none in the summer, and 1964 as a year in which two major runoff periods were present - one in the spring and one in the summer caused by heavy rains.

The values portrayed on the graphs may not be correct since precipitation intensity and local surplus concentration cannot be allowed

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[24] C. W. Thornthwaite and J. R. Mather, op. cit., pp. 193-194.

[25] Very little information on rates of runoff, as distinct from amounts of runoff, for various types of agricultural cover has been found in the literature. Only occasional oblique references have been noted as in A. B. Conner et al. Factors Influencing Runoff and Soil Erosion. Texas Agric. Expt. Sta. Bulletin 411, 1930.

A more recent source is A. R. Croft and L. V. Monninger, "Evapotranspiration and Other Water Losses on Some Aspen Forest Types in Relation to Water Available for Stream Flow." Transactions, American Geophysical Union, Vol. 34, No. 4, August 1953, pp. 563-574. These references lend some support to the assumptions made.

THE PROBABLE DISTRIBUTION OF SURPLUSES UNDER THREE TYPES OF GROUND COVER.

1946

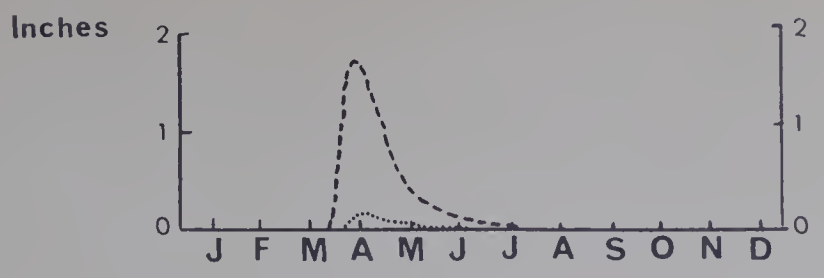


FIG.18

1958

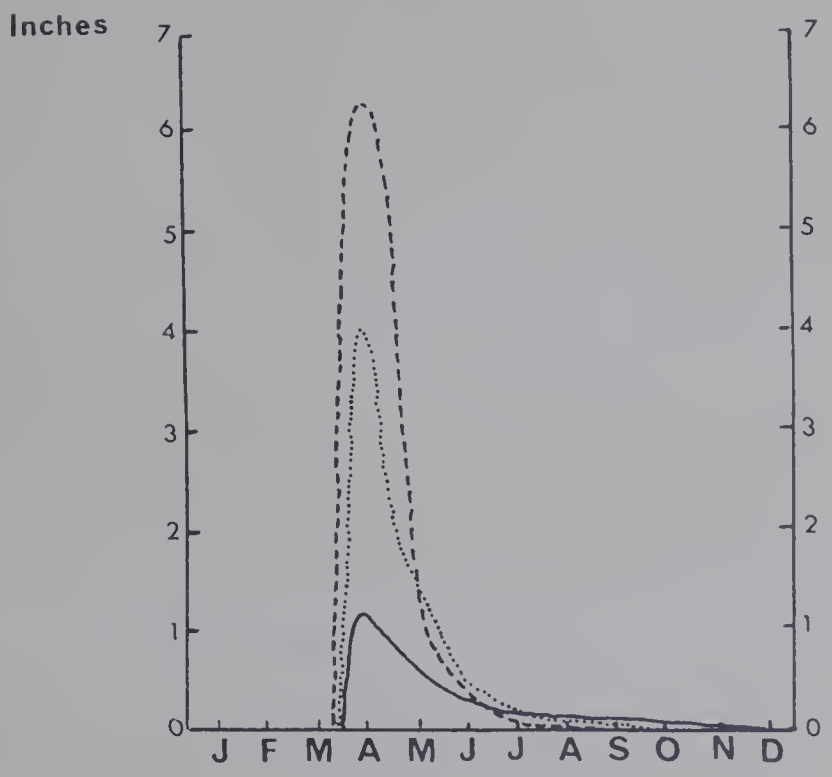


FIG.19

1964

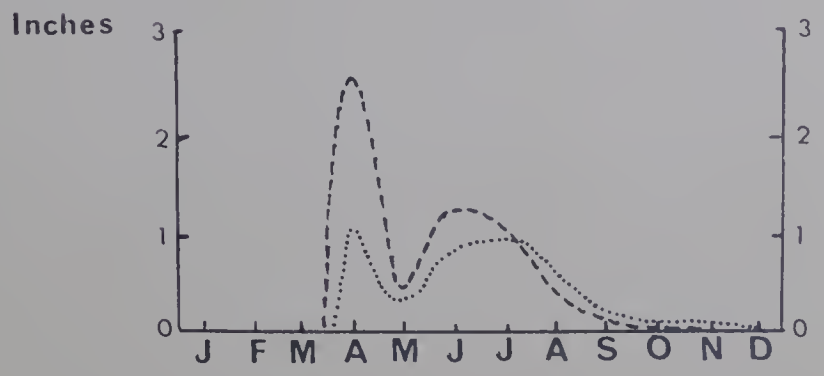


FIG.20

----- Cereals (2" Storage - 75% Runoff in each month)

..... Alfalfa (4" Storage - 65% Runoff in each month)

——— Forest (8" Storage - 50% Runoff in each month)

Compiled from Dept. of Transport Monthly Meteorological Reports for Grande Prairie, 1946, 1958, and 1964 with surpluses taken from Fig.17 in thesis.

for, but the general trends are illustrated. Runoff from an area of shallow rooted crops will result in a peaked hydrograph with most of the runoff occurring in a short period. A pronounced peak development can also be seen in a forage crop area but more water has been retained by the root zone and detention storage is slightly more efficient so flow is spread over a longer period. In a forested area a snowmelt maximum can still be seen but the amount of the surplus is very much smaller, the likelihood of widespread flooding is much less frequent and flow is distributed through more months of the year.

Most basins, which will include this one in the future, are made up a composite of all these variables which, when they are combined with local variations in snow depth and storm rainfall frequencies and intensities, make a complete stream hydrograph rather difficult to deduce. However some of the problems of water management are illustrated by these figures and by this chapter as a whole. A spring-peaked hydrograph is the commonest type for small streams in the Peace River area, and as more land is developed the peaks become more pronounced and the consequent dangers from flooding, erosion and sedimentation are increased. When large areas are opened up the results become noticeable in the major streams which have their hydrographs altered accordingly and they probably also suffer a marked deterioration in water quality. Downstream water use is still not highly developed but this will not necessarily always be the case. If conservation measures are employed from the start any future water uses can be safeguarded in advance. The alternative, i.e. costly watershed management and soil rehabilitation schemes being

instituted after damage has become serious, is possible but we might learn from the experiences of many areas in the United States in this regard.

CHAPTER FOUR

PROBLEMS WHICH MAY ARISE WHEN DEVELOPMENT TAKES PLACE

The opening up of this area at a future date is almost inevitable. Some problems or points will therefore have to be borne in mind when this is done. In this chapter an attempt is made to discuss this aspect under three main headings--the uses of surplus water, the potential damage that may arise from surplus water (erosion, flooding, and sedimentation), and climatic problems (water deficiencies and temperature limitations).

a) The Uses of Surplus Water

In Alberta use for domestic purposes takes priority over all others, and this is followed by municipal, industrial, irrigation and hydropower uses.[1] Other demands on water such as recreation, wildlife, fishing, and navigation receive lower ratings. Allocation of water, however, has not been a real problem up to the present since the level of use compared with the supply has resulted in few conflicts of interests. Only some of these water uses are likely to receive consideration in the Spring Creek area.

Domestic uses will be very important. The farm households and livestock will probably draw their water from wells, dugouts and stockwatering dams. The prospects for all of these methods seem reasonably good at the moment. Wells may be bored where seismic

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[1] Per Gisvold, A Survey of the Law of Water in Alberta, Saskatchewan and Manitoba. Economics Division, Canada, Department of Agriculture, Publication 1046, May 1959, p. 29.

shot-hole logs and any other exploratory data show lenses or layers of gravel to be present. They may be bored where groundwater seepage would indicate the presence of water near the surface, or they may penetrate through to the bedrock if future investigations reveal favourable quality and quantity characteristics. Dugouts can be excavated in sites chosen to receive water from a rather larger area. The common clayey subsoil should render base sealing either unnecessary or comparatively inexpensive in many cases. Stockwatering dam sites, as mentioned earlier, are relatively numerous on the streams. These may not flow for very long in the year but if a proportion of the spring runoff could be trapped then, in addition to its use on the farm, the water so retained would help to reduce the potentially damaging spring peak flows.

The use of surplus water from this basin for local municipal purposes is rather unlikely in the foreseeable future. There are few towns and villages nearby and in any case larger streams and lakes would provide better sources.

There are no major industrial users of water yet in the Peace River area. This position, however, could change quite radically in the future when the possibilities of processing plants moving into the area to take advantage of a plentiful water supply, or the production of hydroelectric power, should not be discounted. Sustained flow throughout the year and sediment-free flow are best for these uses rather than a high basin yield that is concentrated in a short season. It is also the objective in land use conservation practices to achieve these conditions so there should be little conflict of interest.

Another attractive proposal that may see further development here is from solids pipeline experiments. If raw materials such as wood pulp (or chips), coal, Pine Point ore, etc. are to be exported, Peace River water could also be exported as the transporting medium through the pipeline and purified at the other end. This, however, and other diversion proposals as envisaged in P.R.I.M.E. are still in the speculative rather than in the planning stage.[2]

Water from Spring Creek basin and probably from the Simonette is not likely to be directly used in industrial or diversion projects. However, if large additional areas are cleared further and further into the Green Zone, flow patterns and sediment loads even for the major streams could be radically affected. The developers of small basin areas, particularly experimental basins, should bear present and future downstream water uses in mind when various land utilization and conservation recommendations are made.

Water use for irrigation is unlikely to be greatly developed either in the Spring Creek basin area or from the larger streams of the Peace River area as a whole. The degree of incision means that only areas such as Watino and Peace River town could receive water without paying high pumping costs. Use from the smaller streams on the higher land before incision occurs is also unlikely since the rainfall is usually sufficient for some crop on all soils. Irrigation would therefore only

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[2]Outlined in an interview, on the Prairie Rivers Improvement and Management Evaluation programme, given by the Hon. Harry Strome, Provincial Minister of Agriculture, and reported in the Edmonton Journal, Jan. 27, 1966, p. 23.

be a slight supplement to direct precipitation and under these conditions irrigation is usually at its least successful. Farmers tend to take chances with the water and many prefer to do without it. The installation costs for an irrigation network would therefore be too costly for the little use that would be made of it.[3]

As far as navigational use is concerned the days for this, even on the Peace River, are virtually over with the construction of new roads to Hay River and Fort McMurray, and also with the Pine Point railway.

Very little water in the Spring Creek area is well situated for recreational use. The creeks are too small and the lakes are shallow and often intermittent. Even the large lake in the north is shallow and since there is little inflow and outflow to keep it fresh, it will be virtually useless for swimming, etc. for this reason alone, especially later in the summer period. There is some possibility for fishing both in the creek itself and in the lakes that now exist on the minor streams. If these lakes are retained as streamflow regulating basins then it may be possible to have some minor recreational attraction in this way.

Some consideration will have to be given to the claim of wildlife to local water supplies. The various lakes, especially the largest, could be excellent for duck and so also could the smaller ponds in the kame moraine area to the north of the basin itself. The beaver population will probably decrease drastically after the area is opened to

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[3] Some use of sprinkler irrigation for vegetable production is made on alluvial land near Peace River town. The prospects for future expansion of this specialised product have not been rated very highly.

settlement. A few of their dams are in areas which form potentially useful cropland,[4] and others are in areas where they may be replaced by more permanent structures as streamflow regulators.

Other forms of wildlife are also bound to decrease. Deer, moose and other game which have been, and are being, hunted by Indians of the Sturgeon Lake Reserve will no longer be available as an added source of food. The settlement of this and other neighbouring basins will therefore affect the present mode of life of the Indians to some extent.

In summary, the uses of water that are most important and most likely are for domestic purposes and to a much lesser extent for wildlife and recreation (fishing). Other use potentials in the future, however, should be also borne in mind such as possible hydroelectric power and industrial demands downstream. If precautionary land and water conservation measures are taken from the start then regime and quality considerations for these future users can be safeguarded.

b) Potential Damage from Surplus Water--Erosion

The rate of erosion can vary, among other things, with the plant cover, soil type, slope, rainfall amount, rainfall intensity, and rapidity of snowmelt. When the plant cover is dense, i. e. a forest or grass mat which covers the ground completely the soil loss caused by erosion is usually very small indeed. With grain or vegetable row

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[4] For example in Section 1, Tp. 69, R. 25, and Section 1, Tp. 69, R. 26. Some potentially useful agricultural land near the Green Zone boundary in other parts of the Peace River region suffers from flooding as a result of beaver action.

crops the potential for soil removal is increased and on fallow ground it is usually at its maximum. The ability of rainfall to detach and carry soil particles also varies with soil texture and structure. Clay particles are the most readily carried by running water once they are dislodged. However, clay in the presence of organic matter tends to form large aggregates which are more difficult to transport unless broken down by poor soil management. Sand and silt, despite their larger particle size, do not possess the same degree of cohesion as clay soils and do not form aggregates as readily. They can therefore suffer erosion if wind, rainfall or ground cover conditions are favourable.[5] Other soil characteristics such as rate of infiltration, content of organic matter, amount of moisture present, and the permeability of the subsoil can also affect the rate of erosion.

Slope is of paramount importance since the rate of flow of any water that cannot penetrate the ground depends on the slope of the land surface. The greater the speed of water movement the larger are the particles that can be carried in suspension or as bed load in a rill or gully. In one experiment an increase in slope from 6 to 8.48 percent caused an increase of approximately 100 percent in soil erosion.[6] Slope can even influence splash erosion as well as sheet and gully erosion.

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[5] J. A. Toogood and J. D. Newton, Soil Erosion in Alberta. University of Alberta, Faculty of Agriculture, Bulletin No. 56, June, 1956, p. 7.

[6] H. H. Krusekopf. The Effect of Slope on Soil Erosion. Univ. of Missouri, Agricultural Experiment Station, Research Bulletin 363. April 1943, p. 18. A corn, wheat, clover rotation was employed in each case.

Some examples of soil erosion can already be seen in the Spring Creek basin (photos 18 to 22, and 24 and 27). It occurs mostly on roads, at the edge of roads, and in areas where cattle graze. There is a little where seismic lines dip down into the valleys to cross streams. This problem will be more widespread later when cultivation takes place, no matter how carefully it is done. Conservation planning involves the reduction of soil erosion to acceptable minimum levels. It is felt that, from the evidence acquired last summer, soil erosion in the Peace River area as a whole is above this acceptable minimum on the various types of soil studied. The evidence provided by the farmers' questionnaire replies gives some of the information on which this statement is based.[7]

About 120 questionnaires were returned and some included such a variety of soils that no one could be said to be dominant. Ninety fitted into the main groups shown on Table V and it can be seen that the numbers reporting water erosion are especially high.

The percentage and number reporting water erosion is particularly noteworthy for Braeburn soils, perhaps because in many areas these are among the most recent to be settled and the amount of sloping land is rather high.[8] The two main causes reported were spring runoff and heavy summer rains. Damage caused by the latter was heavier in June than in any other month. Summerfallow land was commonly noted as being the

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[7] More than 660 questionnaires were sent out so the return was under twenty percent. This was rather disappointing but was probably inevitable since the mailing had to be done just before harvesting operations started. Statistical methods and correlations have not therefore been carried too far since it cannot be assessed whether or not the returns constitute a representative cross-section of the original list of farms.

[8] For example around the slopes of the Saddle Hills or near Snipe Lake.

first land to suffer. A few farmers reported gullies between one and two feet deep on their land and all of these farms have slopes in the gently rolling category. This amount of slope is also common on Braeburn soils in the Spring Creek basin (see Maps 4 and 5). The two who reported wind erosion were situated on an exposed shoulder of the Saddle hills and they mentioned that it occurred on summerfallow land which was worked too finely.

TABLE V

FARMERS REPORTING EROSION ON CERTAIN SOIL SERIES IN THE PEACE RIVER AREA

Soil Series	Number in Category	Number Reporting Water Erosion	Number Reporting Wind Erosion
Braeburn	18	18	2
Codesa	29	23	3
Donnelly	25	16	5
Culp	11	4	4
Codner	5	5	0
Goose	2	2	0

The largest group of farmers who replied had farms on which Codesa soils were dominant. The percentage reporting water erosion was again high and, when the degree of slope as recorded by the various reconnaissance soil survey reports was transferred to the questionnaire, it was found that water erosion was by no means restricted to land with

a slope of over two percent.[9] Reports of gullied land, however, increased with an increase in slope. Where slopes were in the level to undulating class it was common to find gullies between one and three feet deep and in the most extreme cases, that of a farm with slopes ranging between two and thirty percent, the gullies were five feet deep. No detailed information is available on what types of crops were present in the fields which suffered the most erosion but it would appear from Table VI that the amount of land under grain on the sandy Codesa soil was much less than on the clay loam Braeburn.

TABLE VI

THE PROPORTION OF FARM REVENUE OBTAINED FROM THE SALE OF VARIOUS PRODUCTS (Expressed as a Percentage)

Soil Series	Grain	Livestock & Livestock Products	Grass Seed	Fodder	Other & Unspecified
Braeburn	45	19	28	4	4
Codesa	25	42	22	3	8
Donnelly	40	16	25	13	6
Culp	20	61	4	3	12
(Codner)[10]	(20)	(40)	(30)	(10)	-

[9]Quite a number of farmers quoted various ways of measuring slopes. The degree of correlation with the reconnaissance soil survey maps was high so it was felt that the values obtained from these maps could be transferred on to all the questionnaires and thus have an accurate measure of the slope on each farm.

[10]The fewness of the Culp returns and the lack of precision in some of the revenue statements probably render this column less accurate than the others.

Despite the concentration, therefore, on livestock and grass for seed production a degree of erosion which might be termed slight to moderate was present even in the gently rolling category on Codesa soils. The reply from the Grande Prairie District Agriculturist (Appendix VIII) and photos 14 and 15 would tend to support this viewpoint.

The replies from farmers making a living from Donnelly soils portray a somewhat similar picture. About two-thirds report water erosion and one-fifth mention wind erosion, a greater number than for the previous soils considered. The latter was described as happening sometimes in the fall or in the summer when summerfallow was employed, and in one case a moderate amount occurred during the summer with a low flax cover (Appendix IX).

There are no great areas of Culp soils farmed within the Peace River area so the number of questionnaire replies was small. Surprisingly few for such a sandy area, often along the edges of incised river valleys, reported water or wind erosion. However, where trouble was noted it was often serious. Out of the four farmers whose land suffered from water erosion one had gullies six feet deep (six to fifteen percent slopes) and another mentioned gullies deep and wide enough to hide a truck (six to fifteen percent slopes along an eroded valley edge). Four reported wind erosion which they classified as "moderate" occurring mainly in the spring and on summerfallow land later in the year. Dr. Hoyt mentioned that he had seen Culp soils which were being farmed near Watino, drifting quite badly in a high wind.[11] The drought

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[11] Interview with Dr. P. B. Hoyt, Beaverlodge Experimental Farm, July, 1965.

conditions which these sandy soils can suffer,[12] when added to the erosion dangers under a grain crop, have forced the farmers to base their income mainly on the production of livestock and livestock products with grain being grown less frequently than elsewhere and only to provide a break in the forage crop rotation (see Table VI).

Codner and Goose soils are generally lowlying and moist. No wind erosion was reported but all the questionnaire returns mentioned some degree of water erosion. From the comments made it is obvious that runoff from neighbouring higher land was responsible for damage done to the flats below. Two of the farmers working Codner soil mentioned gullies eighteen inches and four feet deep respectively, due mainly to runoff from other farmers' land over which they have no control. With the degree of slope in the Spring Creek basin area and the amount of lowlying soil of this type a similar problem may exist unless the amount and seasonal distribution of surplus water is in some way controlled. Stockwatering dams upstream would be of some help here.

This section may seem to have allotted too much space to the possibilities of water and wind erosion. It is a problem however that, although frequently stressed in the past,[13] has been neglected by many farmers. In this experimental watershed area and on new ground that will be opened up in the future the problem is almost certain to be more

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[12] Average deficit from Figure 16 was seven inches with a range from zero to twelve inches.

[13] For example in all four reconnaissance soil survey reports for the Peace River area.

serious. Areas with higher snowmelt runoff, with higher summer rainfall, with steeper slopes, with heavy subsoil below a leached A horizon, will be settled so a fairly stringent allocation of land for various purposes will have to be made prior to settlement. However there is a smaller percentage of solonetzic soils in the basin than in areas presently settled so this can be to some extent an alleviating factor.

Summerfallow is frequently cited as a land condition encouraging erosion damage. A number of farmers reported that a change to legume concentration, which cuts out almost all summerfallow, virtually controlled erosion. A further advantage was that grain crop yields were increased in that portion of the rotation because of the greater amount of organic matter in the soil, its greater water retentive capacity, and the loosening effect of the deeper legume roots on the firmly packed subsoil.

Many farmers mentioned the standard means of erosion control--stubble mulches, an increased proportion of the rotation in hay and/or pasture, contour ploughing, grassed watercourses, windbreaks and the provision of drop structures and check dams on some ditches. A few remarked that it should be made an offence, particularly in sandy areas, to remove a windbreak.

Road construction operations seem to have caused a few farmers to experience severe handicaps through increased erosion from roadside ditches, from side ditches cutting back into their fields, through the concentration of runoff causing localised flooding rather than erosion in some cases where roads were inadequately culverted, and through the destruction of trees. Most of the sedimentation and erosion shown on Codesa/Donnelly soils in photos 14 and 15 was caused by roadside ditch action.

Accelerated erosion, caused by man's disturbance of the land, is a problem which will therefore need to be faced in the Spring Creek basin area. Erosion has not yet been severe enough anywhere in the Peace River area (on these soils) to cause abandonment and it can often be reduced, if not eliminated, by a change in crop emphasis. It is, however, in this lack of serious danger that the problem lies.[14] Too many farmers are perhaps inclined to disregard the erosion problem and the district agriculturists' advice altogether. The cumulative effect of many years of slight to moderate erosion could have much more serious repercussions in another few decades. Topsoil, once it is removed, cannot be economically replaced and the loss of much of the already shallow A horizons, together with the more insidious depletion of soluble materials, could accentuate the difficulties of farming especially on the frontier fringe which in some ways is already a marginally economic farming area.

c) Potential Damage from Surplus Water - Flooding

Flooding caused by channel overflow should not pose much of a problem in most parts of the basin that would be suitable for farming. Once surplus water gets to the streams it is usually well below the level of the agricultural land and the risk of flooding is low. Codner and Goose soils in valley sites would be affected but the boggy and sticky nature of these soils would render them more suitable for some moisture tolerant legume cover and they would not often be ploughed in any case.

Flooding caused by poor drainage conditions could be more

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[14] J. A. Toogood and J. D. Newton, op. cit., p. 17.

widespread. The flatter interfluve areas in the southeast, where Snipe soils are common in the hollows on the hummocky till, will experience very slow runoff during the spring meltwater period. Some fields will probably have flooded areas every spring and drainage costs in an area of low land values would probably be too high. The more peaty hollows can therefore be left unused and other areas subject to flooding could be put to hay for use later in the year.

The meadow soils in valley-bottom locations would need a good ditch network, not just to drain them but also to prevent runoff from above spreading over them and causing damage by waterlogging and possibly also by sedimentation. A dense ground cover upstream (mostly grass with forest on steep slopes) would help to delay snowmelt to some extent. Cross-contour furrows, stubble mulches, check dams on ditches where this is possible, and stockwatering dams would all help to alleviate flooding in lowlying areas as well as checking water erosion damage at its source.

As far as agriculture within the basin is concerned these simple points should be sufficient for controlling most flood damage. However, even if the plant cover that will replace trees is mainly a legume and grass cover, the water surplus will increase because of the shallow rooting depth and less efficient surface detention storage. With a number of these basins possibly being opened up in the future district road bridges, culverts, ditches, etc. would have to be planned accordingly. Additional water would reach the major streams especially at peak periods and possible flood damage could be caused to towns downstream, to industrial establishments, and to alluvial flats. All the basins to be cleared,

particularly Spring Creek as a pilot project, should have some network of control structures to detain flow as much as possible. The degree of incision on some of the Spring Creek tributaries should make schemes of this nature quite feasible.

In the Wilson Creek basin study for erosion and sedimentation control, two headwater detention reservoirs were constructed which controlled about fifteen percent of the basin area above the gauging station. In one storm, during which about three inches of rain fell in an eighteen hour period, the peak discharge at the gauging station was calculated to have been reduced by about 35 percent.[15]

Wolverine Creek, Rocky Creek and Bridle Bit Creek all flow through marshy stretches at one time or another in their courses (see Maps 2, 4, and 6). Some drainage of these marshes could be done so that during the summer period when P. E. exceeds precipitation the watertable in the marshes would sink due to the evaporation and transpiration from the phreatophytic growth and also because of the increased drainage provided. When the spring comes the peaty organic matter would act as a sponge to soak up substantial amounts of water in addition to what would spread over the surface. It also seems possible to increase the detention storage on these three creeks by damming them where the valleys narrow after leaving the marshes (see Map 9). In this way flood peaks resulting from either snowmelt runoff or rainfall in excess of infiltration capacities could be detained from just under forty percent

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[15] G. H. MacKay and C. R. Stanton, Wilson Creek Study - Erosion and Sedimentation Control. Water Control and Conservation Branch. Manitoba Department of Agriculture and Conservation 1964, pp. 12-13.

of the area of the basin. If ungated culverts were set in the dam only some hay meadows and muskeg areas would be drowned for periods in the spring, and the meadows in any case would probably be sown with red canary grass or some other water resistant variety.

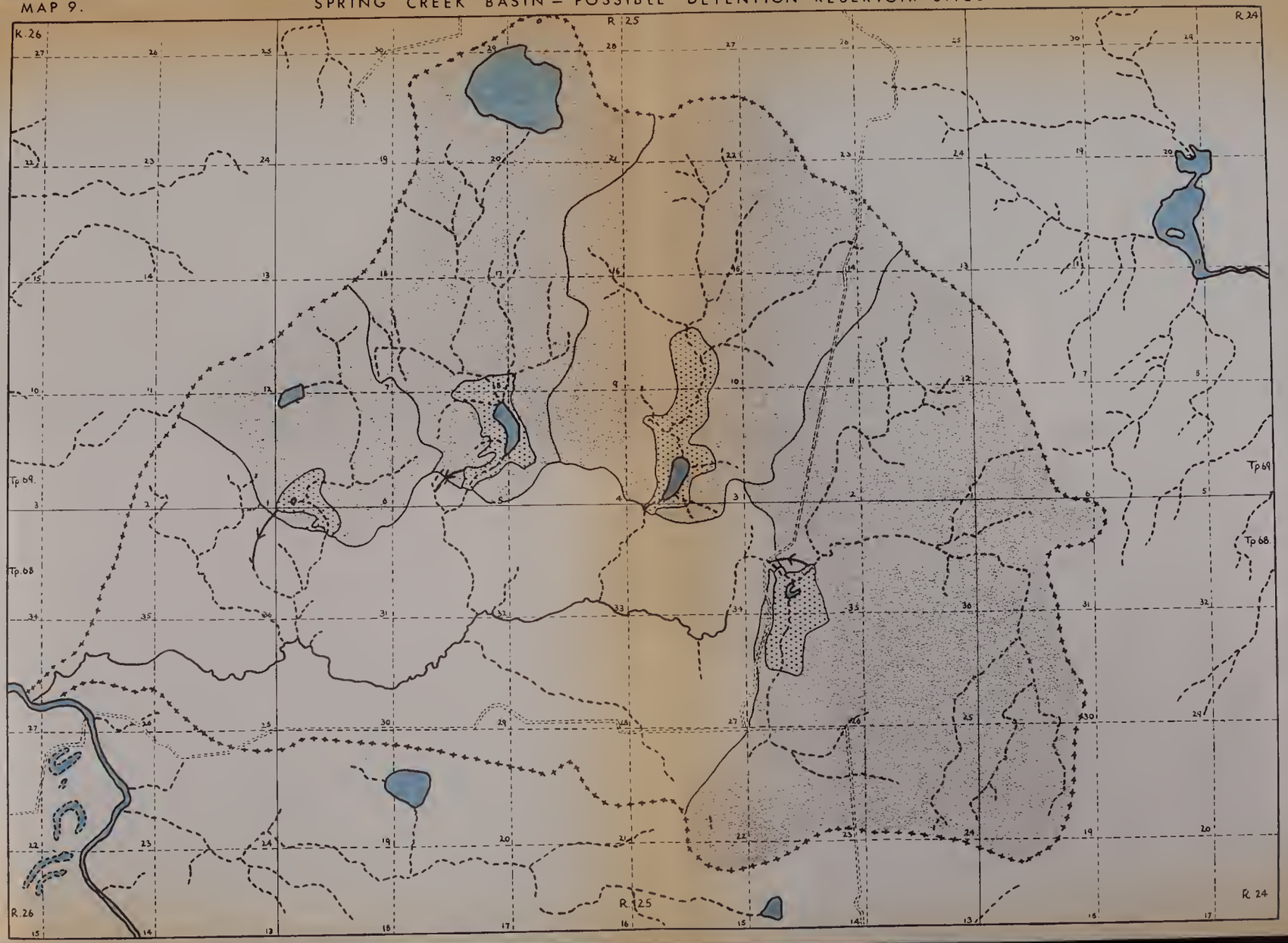
Such a scheme would be expensive, even if practical from an engineering point of view. It need not necessarily be undertaken until several years of experience and records have been accumulated for the area under its natural conditions so that some predictions can be made of its behaviour under agricultural conditions.

Foundation conditions have not been investigated but in each case the length of the dam would be quite small, accessibility because of the new road to be built to the hydrometric gauges would be relatively simple, and in two cases spillway diversion possibilities look quite good. A somewhat similar scheme could possibly be envisaged for the main stream just east of the road crossing. Conditions here, however, are not so favourable. The area capable of being used for storage is small and shallow in relation to the total drainage area, and portions of the road could be washed away unless its location was shifted. On the other hand, with some degree of drainage to improve retention and detention storage in the numerous marshes upstream, a check dam at this point could help to detain some of the flood flow if not all of it.

Detention reservoirs, if employed, would have to be designed to allow a wide margin of safety because of the extreme damage that could result from failure. In the Wilson Creek project it was decided to adopt a design storm of twelve inches of rain over a twelve hour period followed by six inches of rain over a twelve hour period starting

MAP 9.

SPRING CREEK BASIN – POSSIBLE DETENTION RESERVOIR SITES



KEY

AREAS LIABLE TO BE TEMPORARILY FLOODED

BASINS COMPLETELY OR PARTIALLY CONTROLLED

SPILLWAY STRUCTURES

Base Map – Topographical Sheet 83K/13. D.M.T.S., 1960.

thirty-six hours later. Design runoff was obtained by assuming a uniform runoff coefficient of 0.80 over the area tributary to the reservoir. The coefficient was chosen after considering topography, soils and vegetative cover and assuming a moderately saturated soil beforehand.[16] Requirements for the Spring Creek basin may not need be quite so stringent since the potentials for precipitation amounts of this order are less than they are in Manitoba.

Reservoirs of this sort would not be possible in all basins but their widespread adoption could have a great regulatory function on future stream regimes. In many parts of the United States plans of this type are now being drawn up after a great deal of erosion, flooding and sedimentation damage has been done. Less expense is involved in advance conservation than in future rehabilitation so reservation of these sites should be made prior to homesteading settlement.

c) Potential Damage from Surplus Water - Sedimentation

Sedimentation frequently accompanies erosion. It is sometimes separated into overwash (material deposited on top of older soil) and swamping (the material adversely affects the drainage of the older soil).[17]

Reservoirs can have their capacities reduced by sedimentation, transportation facilities can be damaged (road ditches, bridges, and culverts), drainage ditches can be silted up, flood crests can be increased,

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[16] Loc. cit.

[17] F. H. Larson and G. R. Hull, The Role of Sedimentation in Watersheds. Proceedings of the American Society of Civil Engineers, Hydraulics Division. Vol. 83, June 1957, paper 1263, p. 1.

and sediment damage can be done to property. In a virgin area traces of these forms of damage should only be slight. A considerable degree of slumping, however, is present on the steep riverside slopes, one good example being where a forestry road cuts across a steep face (see photo 23). This provides material which in the end finds its way into the stream and is deposited as sediment either within the basin or is carried as particles in suspension into the main Simonette - Smoky - Peace River network.

Some idea of the rather low sediment load carried during normal off-peak periods can be obtained from photo 10. The amount of discolouration of Spring Creek water is more likely to match that of the Simonette during periods of flood. In the future when cultivation is widespread in the basin this sediment load may be greatly increased. The amount of the increase would depend on the practices put into operation for erosion and flooding limitation. Erosion provides the material for sedimentation and flood waters provide the means of transportation for the greatest sediment load. Control over erosion could therefore keep damage caused by sedimentation down to almost negligible levels. Not much damage would be caused to the bottom land in the valleys since little would be farmed in any case. Deposition in field ditches or on flatter ground below a steeper slope, however, is another matter.

The number of farmers reporting these effects can be seen from Table VII. The sloping Braeburn areas appear to be commonly affected in this way, particularly by the washing of finer soil from sloping areas. The degree of damage cannot be assessed from the questionnaire but there must be considerable impoverishment of the soil in the upper and

middle portions of these sloping fields. Codesa areas, too, suffer from soil being washed off the slopes, possibly because of the presence of less permeable material in the subsoil.

TABLE VII

SOME ASPECTS OF SEDIMENTATION ON FIVE PEACE RIVER AREA SOIL SERIES

	Trouble with Ditches Silting up		Finer Soil Washed off Slopes to Bottom	
Soil Series	Yes	No	Yes	No
Braeburn	8	8	10	7
Codesa	8	21	12	17
Donnelly	8	17	5	18
Culp	1	10	2	9
Codner	2	3	3	2

The damage to these areas is not so much due to the sedimentation as to the erosion. The soil, if deposited in a flatter area which may be Codner or marsh can sometimes help to add some beneficial inorganic matter to these soils but a year's crop may be flooded out in the process. On the other hand, if the washing action has proceeded to a greater degree the deeper gullies will have eroded to the C horizon and this type of material can greatly reduce the productivity of an area over which it is deposited.

Flooding may be accentuated by the silting up of ditches. The drainage channels can no longer cope with the flows they were designed to take. Roads and other fields could be affected by this overflow so the initial farmer might not be alone in suffering damage.

Another source of damage could be to future water users downstream. Any sedimentation danger should therefore be controlled from the outset. Conservation practices for erosion limitation would be especially necessary on Braeburn and Codesa slopes. Any material which was removed despite these precautions could be trapped in the large areas of marsh which could act in times of flood as sediment settling basins. Detention reservoirs would also aid in this filtering out at precisely the time when the greatest sediment load would be carried.

It is probably very difficult to do much about the slumping along the valley sides. Log crib deflectors could help to reduce undercutting by flood waters but where slumping is caused by saturation of certain areas by groundwater it may be better to accept the problem rather than take any action which could conceivably affect neighbouring well levels. Any use of these eroded areas adjacent to rivers should be avoided except where it is absolutely necessary for road crossings. Even these can be affected by slumping (for example the road to Peace River town, or photo 23 on a much smaller scale) so construction costs could be inordinately high if repeated reconstruction had to be faced.

e) Climatic Problems - Water Deficiencies

Climatic records for forestry lookout stations would suggest that this region receives slightly more rainfall than Grande Prairie or

indeed than most locations being farmed in the Peace River area. The deficits experienced during the summer, however, are still quite high especially for shallow rooted crops on the sandier soils within the basin.

A comparison of the deficit patterns (Figure 17), annual precipitation totals (Figure 7), monthly precipitation amounts (monthly meteorological records), and the average crop yields in Appendix G indicate that a water deficit affected the crop yields in 1944 and 1955 in spring, and in 1945, 1946, 1949, 1958 and 1963 in summer. It was possible to trace the effects of deficit patterns in other years also but in these the effects were partially masked by other influences such as late summer flooding, early killing frosts, or a delayed start in the spring.

An analysis of the questionnaire returns reveals that many farmers look upon the summer water shortage with some degree of concern.

The deficits are most significant on Culp and Braeburn soils. The former is understandable because of its sandy nature and consequent poor retention and detention storage. The latter may be due to the amount of land in slope which may be sufficient to offset any small increase in precipitation caused by the increased altitude. Donnelly and Codesa soils also suffer in occasional summers and the inhibited percolation to depth often experienced on these soils can reduce the soil moisture supplies held over into the summer period.

Deficits, however, should not be over-emphasised. If this degree of drought was the only agricultural hazard arising from climatic

TABLE VIII

THE NUMBER OF YEARS OUT OF TEN IN WHICH CROP YIELDS SUFFERED BECAUSE OF LACK OF WATER

Soil Series	No. of Answers	Spring	Summer	Autumn
Braeburn	16	3	3	0
Codesa	28	2	3	0
Donnelly	24	1	3	0
Culp	10	3	3	1
Codner	5	1	1	2[18]

conditions it would not be a serious problem. Since other climatic conditions can also adversely affect yields in a number of years, then some note should be taken of the limitations that climate can impose on agriculture in the Peace River area. Deep rooted crops such as legumes would experience lower deficits because they would tap deeper soil moisture reserves and also they would provide a more complete ground cover against damage from erosion which can often be heightened in a dry year. The values shown for the proportion of farm revenue obtained from the sale of various products (Table VI) are a partial indication of drought conditions on the more sandy soils (Culp and Codesa) as well as providing some measure of the change in land use in response to erosion and possible soil fertility characteristics.

f) Climatic Problems - Temperature Limitations

The District Agriculturist for the Grande Prairie area stated that the growing season in the Spring Creek area, in his opinion, is

[18] Excessively affected by one very high value.

probably shorter than in the farming areas around Valleyview and Crooked Creek (Appendix VIII). In consequence he hesitated to recomment any variety of wheat for the area and considered that it was most suited to the production of livestock, and feed grain to a limited extent.

The Grande Prairie temperature, frost-free period, killing frost period,[19] and growing season period records would appear to refute this at first sight. However, this station is situated on a very gently sloping, open lacustrine plain whereas there is a high percentage of broken land, long slopes and minor hollows in the Spring Creek basin. Some of these hollows could have a growing season at least fifty days shorter than on slightly higher areas only a few hundred yards away.[20]

The basin area is not around the physical limit of cereal grain cultivation as described by Guitard and Carder,[21] but it probably is close to the economic limit. Temperature conditions do not prohibit the ripening of any of the common crops but they can be held back in some years from producing to their optimum levels. The crops in 1950 and 1952 were previously mentioned as suffering in this respect and so also did the crops in 1949 when late spring and early summer frosts retarded growth in the first half of the season.[22]

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[19] See Appendix II.

[20] See citation to W. D. Albrights' and J. C. Stokers' work at Beaverlodge included under the climatic section of Chapter II.

[21] A. A. Guitard et al. Growth of Spring Cereals in Northwestern Canada and Alaska. Canada Dept. of Agriculture, paper 1220, 1965, 11 pp. A. C. Carder, "Northwestern Canada's Climate: Its Effect on Crop Growth and Development." Agricultural Institute Review. May-June, 1965, pp. 20-22.

[22] See Figure 5, Appendix II, and Appendix VII.

The statistics presented in Table IX show the frequency of frost damage to crops on the soils common to the Spring Creek area but which at the moment are farmed in more favourable parts of the Peace River country.

TABLE IX

THE NUMBER OF YEARS OUT OF TEN IN WHICH CROP YIELDS SUFFERED BECAUSE OF FROST

Soil Series	No. of Answers	Late Spring	Early Autumn
Braeburn	16	2	4
Codesa	29	1	4
Donnelly	24	1	3
Culp	10	2	3
Codner	5	2	4

This degree of frequency would probably be an underestimate for the Spring Creek area. Conditions for experiencing the least frost damage would probably be present on the flat interfluve areas. On the sloping Codesa soils near the creek cold air drainage could inhibit growth in spring more markedly than on the level land above despite the "warmer" nature of the sandy soil.

Profit margins may never be great in any case, especially to small-scale homesteaders, so the production of cash grains should be discouraged when settlement occurs. A farmer who returned one of the better questionnaire replies mentioned that on his farm grain production was not profitable in any year except as livestock feed. This is by no

means typical of the Peace River area as a whole, but he farmed a somewhat depressional site with mixed Codesa and Braeburn soils in an area about ten miles from Goodfare. This meteorological station was mentioned previously as having had an average annual frost-free period of only sixty one days over the past fourteen years. Hay, however, according to the same farmer does well on his land and so does the production of grass for seed. A large proportion of the hummocky and lowlying land in the Spring Creek area is likely to experience climatic conditions fairly similar to those that he stated. A concentration on livestock, therefore, can be recommended by reason of available heat supply for growth in addition to erosion, regime control, and soil moisture considerations.

CHAPTER FIVE

A RECOMMENDED SUBDIVISION OUTLINING SUITABLE LAND USES

Future water uses have been considered in the previous chapter. It has been stressed that the quality and quantity of surplus water available for these uses will be closely connected with land use practices in the basin.

When the subdivision proposed in this chapter was devised all the previous material was analyzed and information gained concerning the Peace River area as a whole was considered as well as the local environment. The soil rating maps of the reconnaissance soil survey reports proved to be of considerable value and so also did the District Agriculturists' and farmers' replies to the questionnaires. A preliminary report submitted, in September 1965, by the author to the Water Resources Branch was later reviewed by the staff of the Lands Division of the Department of Lands and Forests. The comments received have been of great assistance in the construction of the recommended subdivision portrayed on Map 10.

All areas where the slope is greater than sixteen percent are recommended as being better left under forest and it is suggested that the rough broken land adjacent to drainage courses should also be included in this category. Apart from the possibility of some controlled grazing no other agricultural use should be made of this land. The kame moraine area with its gravelly soils, uneven terrain and large proportion of marsh, should be left in its natural state. A small segment of the easternmost part of the pitted outwash plain has been placed

in this category since at the present time it does not even support enough vegetation for grazing purposes.[1] A short stretch on either bank of the main streams should also be left under a forest cover in areas where some incision is present. In addition, near all sharp breaks in slope especially beside streams, a short strip of cover say fifty feet wide should be left to prevent gullying working from below or above.

The major marshes, particularly the larger areas of Kenzie soil where the muskeg can be up to twenty feet deep, should be withheld from cultivation to act as natural storage reservoirs. These areas will act to some extent as streamflow regulators with the potential to reduce peaks during the snowmelt period or during a time of high rainfall intensity. Some degree of ditching could be attempted so that storage capacities for absorbing the following winter's surplus could be increased by the reduction of the watertable within the marsh through high evapotranspiration rates and slow drainage during the summer and autumn months. This arrangement need not interfere with any plans for headwater detention reservoirs.

The area of Heart soils on the crest immediately southeast of the junction of the creek and the Simonette should not have its tree cover disturbed since this could result in blowouts or even in the establishment of live dune conditions if a series of dry years were to occur in the future.

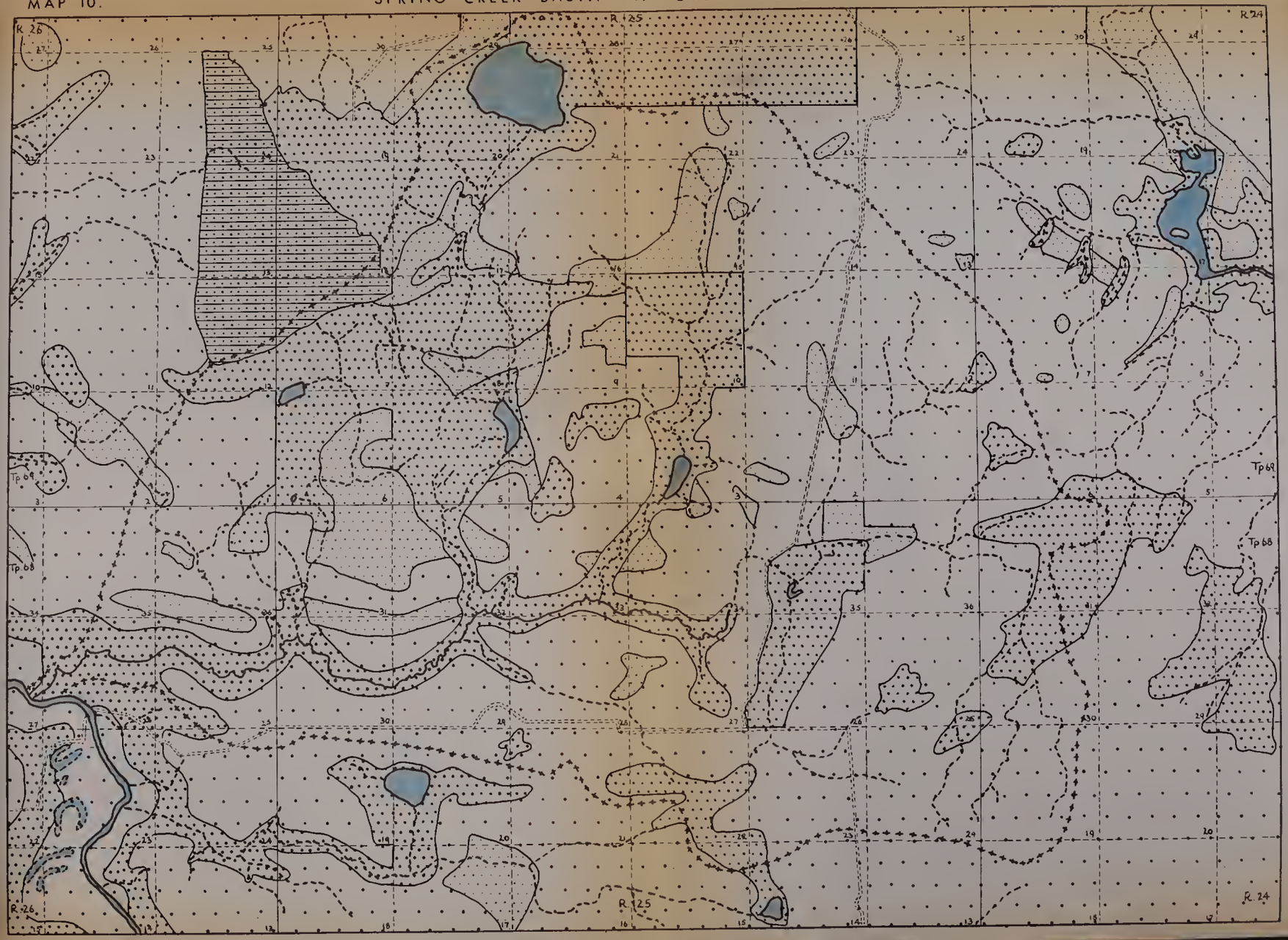
There are some parts of the basin where the tree cover can be

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[1] In Section 28, Tp. 69, R. 25. The use of this gravelly material for road construction purposes in the 1950's has removed what little topsoil existed beforehand.

MAP 10.

SPRING CREEK BASIN — A RECOMMENDED SUBDIVISION



KEY

PRESENT COVER TO BE RETAINED

PERMANENT GRASS INCLUDING HAY MEADOWS

ARABLE LAND WITH FORAGE CROPS PREDOMINANT

ARABLE LAND MORE EQUALLY DIVIDED BETWEEN FORAGE AND CEREAL CROPS

Base Map — Topographical Sheet 83K/13. D.M.T.S., 1960.

thinned for grazing purposes or where it can be removed altogether and the land placed under permanent pasture. Areas in the rolling topographic class, particularly on long slopes greater than nine percent, should be placed under permanent grass from the start rather than pursue a policy of waiting to see if erosion problems will arise. The questionnaire returns would indicate that land of this degree of slope would be better left undisturbed by cultivation practices.[2]

Part of the pitted outwash plain would come into this category, a part in the east where it has still too coarse a soil texture to give good returns from arable farming methods. Some of the smaller and shallower marshy areas have also been included in this category. These soils may be capable of producing grain crops after some drainage has been done but the damage from periodic flooding and frosts could be severe. The use of these areas as hay meadows seems more advisable and it would still be possible for them to act as moisture storage basins although to a lesser extent than the deeper organic soils.

Any minor incipient gully patterns which develop after clearing may also be put under permanent grass. This is not always necessary unless it appears that a hitherto almost unnoticed hollow is acting as a watercourse in times of flood.

Most of the rest of the basin has been placed in the category delimiting areas where arable use is quite feasible but the production of

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[2]New growth of trees in these areas set aside for permanent pasture could be kept down in part by the grazing animals themselves and supplemented, when necessary, by periodic controlled burning which was mentioned earlier as bei ng a method presently used for clearing scrub from community pasture land.

forage crops and legume and grass seed should predominate over the production of cereal grains. This conclusion is borne out by almost all the evidence accumulated earlier. The District Agriculturists suggested a livestock economy for the area. The plants concerned can stand the shorter growing season that the area is likely to have when compared with Grande Prairie or even Sturgeon Heights. The damage caused by erosion and sedimentation would be less on the sloping terrain than with grain crops, any summer moisture deficits would be less intense and the water surplus would be smaller and slightly more evenly distributed throughout the year.

In addition to the evidence accumulated during the study it has been proposed elsewhere that if recommended land use and cropping practices were to be followed on the Upper Peace River region land under cultivation,[3] then land use in 1960 would have required adjustment as follows:

Wheat acreage	- 25%
Oats acreage	- 18%
Barley acreage	- 8%
Fallow acreage	- 28%
Forage crop acreage	+ 95%

Most of the additional forage crop production would have to be

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[3] C. F. Bentley, Present and Future Agriculture Production in Alberta's Peace River Area. "The Changing Frontier" - a conference at Peace River, 5-6 October, 1965, p. 25 and quoting Mr. E. C. Stacey, Superintendent of Beaverlodge Experimental Farm in 1960. The area described also included neighbouring agricultural land in British Columbia.

marketed through livestock rather than through seed.[4] It is felt that there will almost certainly be an increased market for the extra numbers of livestock produced especially as transportation facilities with the West Coast are improved and the population there grows.[5]

A farming economy with a livestock base would therefore seem best suited to the Spring Creek area. The ground cover associated with this type of farming (with grasses and legumes possibly grown for three years, followed by one year of grain, and then back to grasses and legumes, probably with a cereal nurse crop)[6] would have a considerable effect in reducing any soil loss through erosion to acceptably low levels. The only time when the land would be fallowed would be between the time that the clover and grassland was being broken (say in July) in preparation for the seeding of the grain crop in the next spring. Most of the undulating and gently rolling topographical subdivisions would be in this category and it would also provisionally include the alluvial lowlands in the Simonette valley. The soil texture, depth and drainage characteristics, however, are so varied in this latter region that changes in category may be made later as experience in the area is gained. The lowest level, especially along the western bank, could be subject to flooding so a change to a more permanent grass cover may have to be envisaged if this becomes a severe problem.

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[4] Loc. cit.

[5] G. R. Purnell. Future Markets for Northern Alberta's Agricultural Products. "The Changing Frontier" - Conference at Peace River. October, 1965, p. 36. Reference was made specifically to the area around Grande Prairie, not the B. C. portion of the Peace River region.

[6] Appendix VIII, Grande Prairie District Agriculturist.

One area of Donnelly soil has some advantages over the rest of the basin for agricultural purposes. It is almost level in the east with a slight slope to the west which only near the western margin becomes as much as two percent. It is an altitude of about 2500 feet and is therefore less subject to frost than most lower parts of the area mapped. It does not have significant undulations which could form minor frost hollows themselves. It may be a more difficult soil to work but it should raise better crops, be capable of carrying a higher percentage of grain in the rotation, and the economic prospects of the farmer should be slightly better than elsewhere in the basin with the same amount of land. Forage crops may not need to be dominant on this area of soil so it is differentiated from the rest of the mapped area by recommending a more equal distribution of time under grains and under forage crops.

The subdivision in which suitable land uses have been outlined has been kept down to four groups for the sake of simplicity. The patterns portrayed represent a compromise. Conservation and regulation of the land and water resources must be practised but not to the extent that they seriously restrict the attempts of the coming homesteaders to obtain a satisfactory living from the land. An acceptable standard of prosperity, however, does not depend on farming methods alone. Sufficient land must also be available.

Large farms, each one section in extent, are recommended. The farmers' questionnaire replies, when averaged for each of the major soil series, gave values close to this amount.[7] The District Agriculturists

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[7] Codner soil series was an exception. Two to three quarters were recommended from only five replies.

also mentioned four quarters with, in the case of Culp, some extra summer grazing land being required. This may be obtained from the areas recommended as suitable for being left under forest or permanent grass. Most of these are not large enough to be organized into a community pasture but some limited-use lease arrangement could probably be made rather similar to the small-scale Spring Creek Grazing Association which leases land near the mouth of the creek at the moment.[8]

Farm sizes have been growing larger in the Peace River area, partly through buying out a neighbour and partly through purchase of uncleared land nearby. At the moment, as the law stands, a homesteading applicant and his spouse may not apply for more than three quarters of land.[9] It will take quite a few years before this amount can be worked and the farmer can hope to break more ground. An added quarter or more can be obtained by direct purchase from a neighbour or from the government. The latter is more likely but the land is often a number of miles from the original farm. It would be more efficient in the long run if the farmer at the start could obtain a block of four quarters and the uncleared land could be used for grazing prior to clearance. This would enable the establishment of farms large enough to meet the minimum economic size which, with present methods, is thought to apply to this physical environment. Temporary off-farm employment is often sought during the initial stages of creating a farm but the homesteader, when

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[8] In Sections 31 and 32 Tp. 68, R. 25, Section 36, Tp. 68, R. 26, and Sections 1 and 2, Tp. 69, R. 26.

[9] W. Odynsky, C. D. Sawyer, and V. A. Wood. Public Lands Open for Settlement in the Peace River District of Alberta. Alberta Dept. of Lands and Forests, May 1964, p. 32.

all the arable land has been cleared and seeded, should no longer be obliged to keep up this practice because of any financial restrictions which may be imposed by his limited acreage.

Future road networks have not been mapped since deviations from the normal sectional grid may be necessary near Spring Creek and the Simonette because of the steepness of the slopes. It was thought at one time that part of the basin should be subdivided on the basis of topography rather than on the usual rectangular pattern. However slopes are probably not steep enough, nor would the basin be sufficiently fragmented by Crown land withheld from settlement, to warrant a proposal of this nature.[10]

Windbreaks can follow the road network and can also be planted around the buildings. Little additional shelter belt protection should be required, at least not for wind erosion purposes, with the land use pattern recommended previously. The broken topography and the amount of land left under a tree cover should prevent the development of a great enough fetch for this problem to arise.

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[10] The areas to be left under their present cover would constitute land to be withheld from settlement.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

Throughout this study it has been assumed that land in the Spring Creek area will be opened up for agriculture in the not too distant future. The staff of the Lands Division of the Department of Lands and Forests considered this fact to be almost inevitable when the basin was chosen by the Water Resources Branch as an International Hydrologic Decade research project.

In summary, information has been collected concerning the physical resources of the basin. From this, and a study of similar soils being farmed elsewhere in the Peace River area, a plan was proposed allotting the land to the use for which it seemed best suited. This recommended subdivision really forms part of the conclusions reached.

Some attempt has been made to evaluate the effect of agricultural development on the runoff and erosion characteristics of land presently under forest cover. Annual water deficits and surpluses have been calculated. Using these data, and comparing them with measured values of streamflow obtained from other basins, an estimate of the annual runoff has been made. It is considered that with the change in cover runoff will increase in the future. The increase will not be throughout the year but mainly during the periods, such as the spring, which already have high flows. A more peaked hydrograph will therefore be developed.

Various means of limiting erosion and flooding damage have been recommended. Marshes should be partially drained to act as

improved storage basins especially in the spring. Detention reservoirs should be constructed to regulate the flow during the snowmelt period or after heavy summer rainstorms. The growth of forage crops has been proposed as a measure for utilizing more water, so reducing the surplus and also promoting better surface detention than would be the case with a cereal cover. It is advocated that measures of this sort should be more widely applied as settlement moves outwards from its present centres so that an increase in agricultural land need not necessarily mean increased flood flows in the major streams. In this way some measure of regime improvement has been suggested for the local good and also to prevent the growth of problems which may affect future water users downstream.

Some data on erosion have been accumulated by visiting other farms on similar soils and by sending out questionnaires to District Agriculturists and farmers. Soil erosion is almost certain to increase within the basin after the land is cleared. It is likely to be more serious than in areas from which questionnaires were received, principally because of the amount of sloping terrain and the slightly higher precipitation present. Steeply sloping land (with slopes greater than sixteen percent) should be left under forest. Rolling terrain (with slopes mainly between six and sixteen percent) should be placed under permanent grass, and most of the rest of the basin should be cultivated using a rotation in which forage crops are dominant. Wooded stretches should be continued for at least fifty feet back from a steep slope and the commonly used methods of erosion control such as check dams, stubble mulches, contour furrows and grassed waterways should also be employed where

necessary. The measures proposed for erosion limitation and regime regulation are complementary. The problems are closely related and so also are the attempts at solution.

Frost hazards are already significant in the Peace River area but they will be even greater in the numerous depressions of this undulating terrain. The land utilization patterns proposed in the previous chapter are adapted to make allowance for this factor. In fact the range of problems that the area may experience all seem to be most satisfactorily subject to solution if proposals for a livestock economy, with the cultivation practices concentrating on forage crops for farm use and for seed, are put into effect.

Involvement in economic considerations and proposals has been kept to a minimum. The physical background of the area and the interactions between it and man's probable modifications of it have been a sufficient field of study on their own. It is felt, however, that a case can be made for increasing the maximum allocation of land for homesteading purposes to four quarters per household on new land now being made available for settlement. In addition, if larger loans could be granted to help with clearing, breaking, and the initial outlay in housing, water, and machinery, then the homestead could become a paying proposition at an earlier date than is now the case. The need for supplementary employment, especially in winter, would be reduced. This in turn would make the raising of livestock a more successful operation.

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PHOTOGRAPHS



Photo 1. Spring Creek looking east from bridge in Sect. 35, Tp. 68, R. 25, W of 5th.

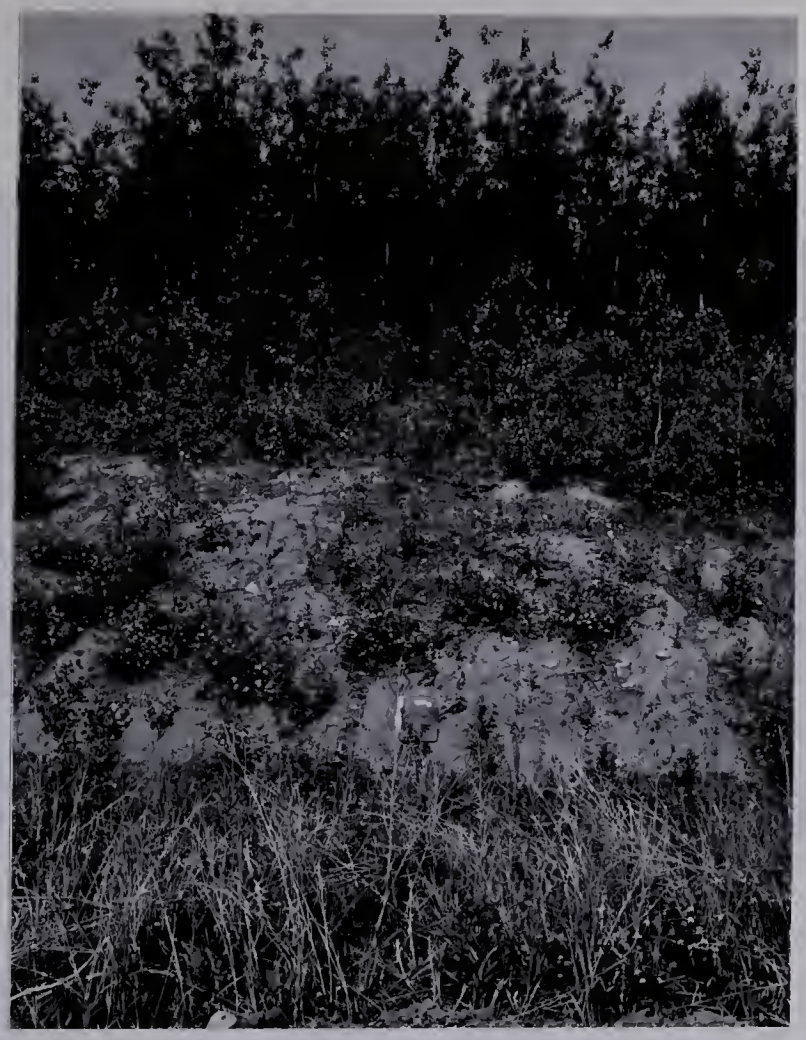


Photo 2. Stony Braeburn exposure with light forest growth above. Clip-board gives scale. S.E. 1/4 of Sect. 11, Tp. 69, R. 25, W of 5th.



Photo 3. Stony Braeburn field, slight slope (about three percent). Sect. 32, Tp. 72, R. 26, W of 5th--near Debolt.



Photo 4. Gullied roadside cutting in rather stony Braeburn. Leached Ae. horizon stands out. Taken along main highway between Grande Prairie and Woking about one mile north of the crest of the Saddle Hills.



Photo 5. Braeburn again, near Photo No. 4. Calcium carbonate accumulation layer prominent. Twelve inch square air photo holder gives the scale in both cases.



Photo 6. Gully erosion near Gordondale resulting from the spring run-off in 1958, on a Donnelly soil area having a 2 per cent slope. Reconnaissance Soil Survey of Beaverlodge and Blueberry Mountain Sheets, page 102.



Photo 7. Gully on Donnelly soil, running off pasture into a small slough. Level land above then short drop with about five percent slope down to slough. Gully about 4 feet deep. N.E. 1/4, Sect. 34, Tp. 76, R. 6, W of 6th.



Photo 8. Looking over Codner/Goose land, approaching Kenzie type soil in the distance. Looking S. S. E. from point 1/3 of a mile East of SW Corner of Sect. 15, Tp. 69, R. 25, W of 5th.



Photo 9. Taken at the same point as No. 8 but looking directly West along seismic line. An abrupt change in slope, change in vegetation and change in soil (to Bb. Do. Co. st. area).

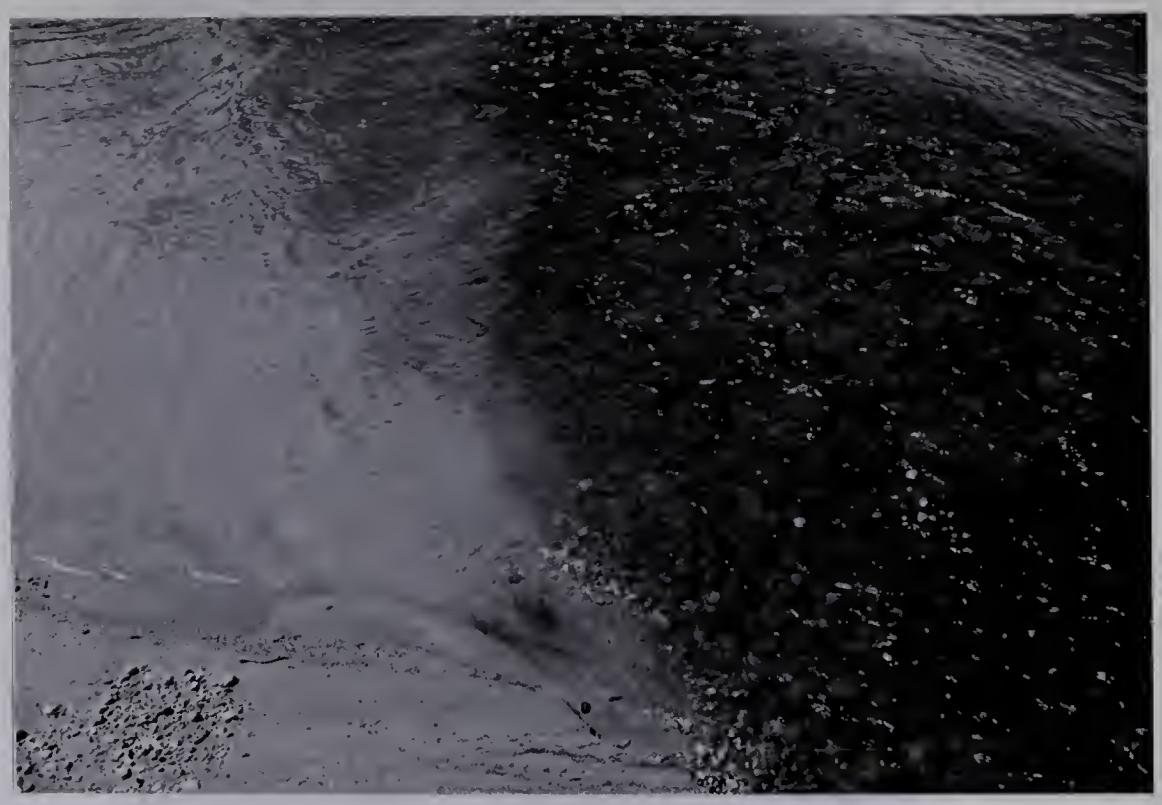


Photo 10. Close-up photo showing Spring Creek water (on the right) flowing into the sediment-laden Simonette River (on the left). Taken on 12th July 1965.



Photo 11. The junction of Spring Creek and the Simonette River.

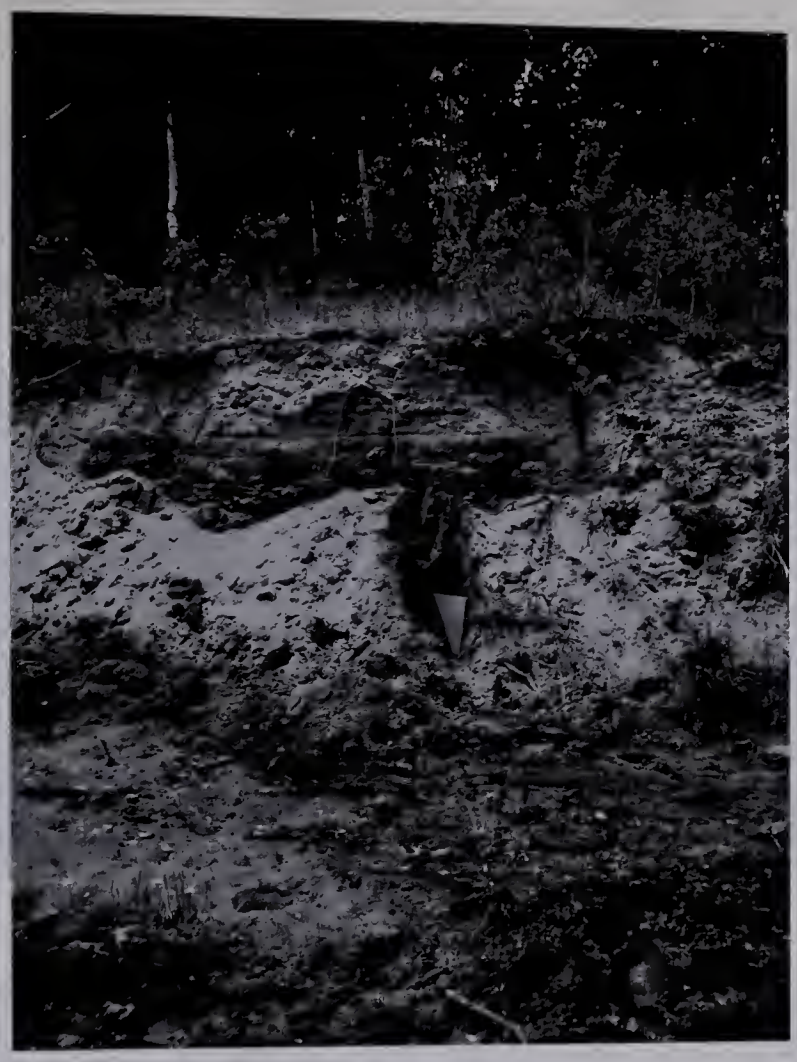


Photo 12. Sand cutting, showing signs of stratification. Air photo holder gives scale. Roadside cutting in NW 1/4 of Sect. 24, Tp. 68, R. 26, W of 5th



Photo 13. Open forest vegetation on top of sand dunes in SW 1/4 of Sect. 25, Tp. 68, R. 26, W of 5th



Photo 14. Roadside ditch completely filled with sediment, spade gives scale. Taken in Co. Do. soils area 6.5 miles SE of Crooked Creek.



Photo 15. Ditch along minor road seen in middle distance of No. 14. Nearer the source of the erosion. Water cutting a new channel in its own "alluvium." Again a Co. Do. area. Clayey substratum impedes percolation, encourages erosion.



Photo 16. Active gully eroding rapidly in fallow field on Braeburn/Esher boundary zone near Woking. Taken on Monday, 28th June after approximately three inches of rain in previous two days.



Photo 17. Close-up view of same gully at field boundary. Gully here is about 4 feet 6 inches deep.



Photo 18. Gully on road in gravel terrace area on the eroded slopes on northern side of Spring Creek. N. W. 1/4, Sect. 26, Tp. 68, R. 26, W of 5th. Air photo holder gives scale.



Photo 19. Gully on sandy material destroying forestry road in SW 1/4, Sect. 35, Tp. 68, R. 26, W of 5th. Air photo holder gives scale.



Photo 20. Gully in mixed material destroying forestry road on 9% slope in NW 1/4, Sect. 26, Tp. 68, R. 26, W of 5th. Photo holder gives scale.



Photo 21. The same gully photographed from the same point three weeks later, after the heavy rains (three inches) in the last weekend of June. Air photo holder is in same location.



Photo 22. View of same gully as Photos Nos. 20 and 21. Taken in the gully and nearer the toe of the slope. Air photo holder, twelve inches square, gives the scale.



Photo 23. Slumping along forestry road in "Eroded Land" classification a quarter of a mile SE of Spring Creek in Sect. 26, Tp. 68, R. 26, W of the 5th.



Photo 24. Minor gully in road in Braeburn soil area on slope of approximately five percent. SE 1/4 Sect. 28, Tp. 68, R. 25, W of the 5th.



Photo 25. Fairly dense aspen cover, 30-60 ft. high, which may present some added expense in clearing. Taken near No. 24 in SE 1/4 Sect. 28, Tp. 68, R. 25, W of the 5th.



Photo 26. Recent slumping (caused by rain at the end of June) along a minor creek in SW 1/4 of Sect. 31, Tp. 68, R. 25, W of the 5th. This part of Spring Creek basin is heavily grazed by cattle. Recovery of tree growth after fire is therefore inhibited.



Photo 27. Gully in same quarter section as Photo No. 26. Caused by concentration of water in path trodden by cattle on way down to creek. Clip-board gives scale.



Photo 28. "Land" behind a beaver dam in SW 1/4, Sect. 17, Tp. 69, R. 25, W of the 5th.



Photo 29. Concrete spillway structure for controlling large volumes of water and reducing erosion. Taken at point 2-1/2 miles west of Teepee Creek road junction with Highway 34.

APPENDICES

APPENDIX I

THE DETERMINATION OF THE ELEVATION-AREA AND SLOPE-AREA GRAPHS (Figures 1 - 3)

Area-elevation data can be assembled by planimetering the area between contours on topographic maps. Equally satisfactory results can be obtained by the use of a transparent grid laid over a topographic map and this latter method was used in the construction of Figures 1 and 2. The number of intersections falling within various elevation ranges can be counted and the resulting tally gives a frequency distribution of elevation of grid intersections which, if based on a sufficient number of points, is also a reasonably close approximation to the area-elevation distribution. In Applied Hydrology (Linsley, Kohler, and Paulhus 1949, p. 248) at least 100 points are recommended and in the compilation of Figures 1 and 2 approximately 200 intersections were counted to reduce the margin of error still further.

The same method can be adapted for the calculation of slopes (Linsley, Kohler and Paulhus, op. cit. p. 251). A grid with over 100 contour intersections within the basin should again be used and the frequency distribution of basin slope, normal to the contours at grid intersections, is determined. The distribution of slopes can then be graphically displayed, preferably using a logarithmic scale to include the extreme range from less than 0.5 percent to over 30 percent slopes.

APPENDIX II

GRANDE PRAIRIE - PERIOD FREE FROM KILLING FROSTS
i.e. above 28°F

Year	Last in Spring		First in Autumn		Period in Days
1943	May	15	Sept.	7	115
1944	May	11	Sept.	29	141
1945	May	9	Sept.	24	138
1946	May	14	Sept.	7	116
1947	May	13	August	20	109
1948	April	28	August	26	120
1949	May	17	Sept.	11	117
1950	May	7	Sept.	8	124
1951	June	1	Sept.	14	105
1952	May	6	Sept.	13	130
1953	April	30	Oct.	18	171
1954	May	3	Sept.	17	137
1955	May	14	Sept.	9	118
1956	May	4	Sept.	24	143
1957	April	21	Sept.	18	150
1958	May	11	Sept.	22	134
1959	May	12	Sept.	28	139
1960	May	5	Sept.	16	134
1961	May	10	Sept.	2	115
1962	May	5	Sept.	2	120
1963	May	3	Oct.	19	169
1964	April	27	Sept.	6	162
Mean	May	8	Sept.	17	132

Source: Dept. of Transport Meteorological Branch. Monthly Records, 1943-64.

APPENDIX III

THE TREND TOWARD INCREASED HAY CROP PRODUCTION

Total Acreage Cropped and Acreage by Principal Crops in the Grande Prairie and Sturgeon Lake Sheets

Year	Total Field Crops	Wheat	Barley	Oats	Rye	Flax	Hay*
1916	16,506	7,047	1,008	7,476	--	185	730
1921	55,841	21,466	3,510	26,263	226	264	1,793
1926	65,749	37,655	2,353	21,260	585	20	2,609
1931	129,418	80,944	2,905	39,706	189	--	2,583
1936	145,535	79,310	6,557	49,183	284	45	5,740
1941	161,016	83,040	10,644	53,398	608	1,554	8,087
1946	186,448	93,748	7,218	63,290	1,223	1,319	16,452
1951	244,950	76,146	26,821	82,271	7,403	6,895	40,004

*Includes clover, alfalfa and cultivated grasses.

Source: W. Odynsky et al. Soil Survey of the Grande Prairie and Sturgeon Lake Sheets.

Acreage by Principal Crops in Improvement District 126

Year	Wheat	Barley	Oats	Flax	Tame Hay	Other Fodder
1956	5,912	13,553	11,403	4,936	8,907	1,054
1961	9,821	14,648	13,289	4,685	17,945	1,670

Source: Census of Canada, Agricultural Statistics, 1956 and 1961.

Spring Creek basin is in I. D. 126 - a subdivision of Census Division 15.

APPENDIX IV

WATER BALANCE EQUATIONS FOR TWENTY TWO YEARS (1943-64) FOR SEVEN SOIL MOISTURE STORAGE CAPACITIES

Grande Prairie - Water Balance Summary - 1" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1943	14.16	20.35	8.50	5.16	-2.85	11.85
1944	17.61	22.29	8.39	2.78	+1.13	13.70
1945	13.25	19.73	11.81	5.18	+0.15	7.92
1946	11.98	20.41	13.16	3.29	+1.44	7.25
1947	19.03	20.12	8.52	8.18	-0.75	11.60
1948	22.29	20.25	5.17	8.26	-1.05	15.08
1949	15.63	20.18	10.91	4.16	+2.20	9.27
1950	16.51	19.21	8.74	5.73	+0.31	10.47
1951	20.75	18.21	5.18	6.75	+0.97	13.03
1952	15.50	20.76	9.51	8.76	-4.51	11.25
1953	18.58	19.68	6.98	4.67	+1.21	12.70
1954	18.91	18.83	5.47	5.87	-0.32	13.36
1955	18.34	19.50	6.80	2.96	+2.68	12.70
1956	17.75	20.06	8.05	6.89	-1.15	12.01
1957	22.94	19.54	5.88	4.56	+4.72	13.66
1958	17.71	21.44	9.09	9.59	-4.23	12.35
1959	13.57	19.45	11.13	6.46	-1.21	8.32
1960	17.24	20.80	8.72	5.92	-0.76	12.08
1961	19.02	20.54	6.11	3.16	+1.43	14.43
1962	20.12	20.04	6.29	5.62	+0.75	13.75
1963	14.68	20.13	12.65	8.33	-1.13	7.48
1964	26.74	19.99	0.08	7.04	-0.21	19.91
Total	392.31	441.31	177.14	129.32	-1.18	264.17
Average	17.83	20.06	8.05	5.87	-0.05	12.01

Source: Dept. of Transport, Meteorological Branch Monthly Records 1943-64 and computed according to Thornthwaite's procedures as published in 1948.

Grande Prairie - Water Balance Summary - 2" Storage

Year	Precipitation	P. E.	Deficit	Surplus	Storage Change	E. T.
1943	14.16	20.35	7.50	4.16	-2.85	12.85
1944	17.61	22.09	6.91	1.30	+1.13	15.18
1945	13.25	19.73	10.81	4.18	+0.15	8.92
1946	11.98	20.41	12.16	2.29	+1.44	8.25
1947	19.03	20.12	7.52	7.18	-0.75	12.60
1948	22.29	20.25	4.17	7.26	-1.05	16.08
1949	15.63	20.18	9.91	3.16	+2.20	10.27
1950	16.51	19.21	7.74	4.73	+0.31	11.47
1951	20.75	18.21	3.76	5.33	+0.97	14.45
1952	15.50	20.76	8.51	7.76	-4.51	12.25
1953	18.58	19.68	5.98	3.67	+1.21	13.70
1954	18.91	18.83	4.47	4.87	-0.32	14.36
1955	18.34	19.50	5.51	1.64	+2.71	13.99
1956	17.75	20.06	7.05	5.74	-1.00	13.01
1957	22.94	19.54	4.87	3.73	+4.54	14.67
1958	17.71	21.44	8.09	8.28	-3.92	13.35
1959	13.57	19.45	10.13	5.34	-1.09	9.32
1960	17.24	20.80	7.27	4.90	-1.19	13.53
1961	19.02	20.54	5.11	2.16	+1.43	15.43
1962	20.12	20.04	5.29	4.62	+0.75	14.75
1963	14.68	20.13	11.65	7.33	-1.13	8.48
1964	26.74	19.99	0	5.96	+0.79	19.99
Total	392.31	441.31	154.41	105.59	-0.18	286.90
Average	17.83	20.06	7.02	4.80	-0.01	13.04

Grande Prairie - Water Balance Summary - 4" Storage

Year	Precipitation	P. E.	Deficit	Surplus	Storage Change	E. T.
1943	14.16	20.35	5.50	2.16	-2.85	14.85
1944	17.61	22.09	5.61	0	+1.13	16.48
1945	13.25	19.73	8.81	2.18	+0.15	10.92
1946	11.98	20.41	10.16	0.29	+1.44	10.25
1947	19.03	20.12	5.52	5.18	-0.75	14.60
1948	22.29	20.25	2.17	5.26	-1.05	18.08
1949	15.63	20.18	7.91	1.16	+2.20	12.27
1950	16.51	19.21	5.74	2.73	+0.31	13.47
1951	20.75	18.21	1.76	3.33	+0.97	16.45
1952	15.50	20.76	6.51	5.76	-4.51	14.25
1953	18.58	19.68	3.98	1.67	+1.21	15.70
1954	18.91	18.83	2.47	2.87	-0.32	16.36
1955	18.34	19.50	3.87	0	+2.71	15.63
1956	17.75	20.06	5.05	3.74	-1.00	15.01
1957	22.94	19.54	2.87	1.73	+4.54	16.67
1958	17.71	21.44	6.09	6.28	-3.92	15.35
1959	13.57	19.45	8.13	3.34	-1.09	11.32
1960	17.24	20.80	5.27	2.90	-1.19	15.53
1961	19.02	20.54	3.11	0.16	+1.43	17.43
1962	20.12	20.04	3.29	2.62	+0.75	16.75
1963	14.68	20.13	9.65	5.33	-1.13	10.48
1964	26.74	19.99	0	3.96	+2.79	19.99
Total	392.31	441.31	113.47	62.65	+1.82	327.84
Average	17.83	20.06	5.16	2.85	+0.08	14.90

Grande Prairie - Water Balance Summary - 6" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1943	14.16	20.35	3.50	0.16	-2.85	16.85
1944	17.61	22.09	5.61	0	+1.13	16.48
1945	13.25	19.73	6.81	0.18	+0.15	12.92
1946	11.98	20.41	9.87	0	+1.44	10.54
1947	19.03	20.12	3.52	3.18	-0.75	16.60
1948	22.29	20.25	0.17	3.26	-1.05	20.08
1949	15.63	20.18	6.75	0	+2.20	13.43
1950	16.51	19.21	3.74	0.73	+0.31	15.47
1951	20.75	18.21	0	1.33	+1.21	18.21
1952	15.50	20.76	4.51	4.00	-4.75	16.25
1953	18.58	19.68	2.31	0	+1.21	17.37
1954	18.91	18.83	0.47	0.87	-0.32	18.36
1955	18.34	19.50	3.87	0	+2.71	15.63
1956	17.75	20.06	3.05	1.74	-1.00	17.01
1957	22.94	19.54	1.14	0	+4.54	18.40
1958	17.71	21.44	4.09	4.28	-3.92	17.35
1959	13.57	19.45	6.13	1.34	-1.09	13.32
1960	17.24	20.80	3.27	0.90	-1.19	17.53
1961	19.02	20.54	2.95	0	+1.43	17.59
1962	20.12	20.04	1.29	0.62	+0.75	18.75
1963	14.68	20.13	7.65	3.33	-1.13	12.48
1964	26.74	19.99	0	1.96	+4.79	19.99
Total	392.31	441.31	80.70	27.88	+3.82	360.61
Average	17.83	20.06	3.67	1.27	+0.17	16.39

Grande Prairie - Water Balance Summary - 8" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1943	14.16	20.35	3.34	0	-2.85	17.01
1944	17.61	22.09	5.61	0	+1.13	16.48
1945	13.25	19.73	6.63	0	+0.15	13.10
1946	11.98	20.41	9.87	0	+1.44	10.54
1947	19.03	20.12	1.52	1.18	-0.75	18.60
1948	22.29	20.25	0	1.26	+0.78	20.25
1949	15.63	20.18	4.92	0	+0.37	15.26
1950	16.51	19.21	3.01	0	+0.31	16.20
1951	20.75	18.21	0	0	+2.54	18.21
1952	15.50	20.76	2.51	3.33	-6.08	18.25
1953	18.58	19.68	2.31	0	+1.21	17.37
1954	18.91	18.83	0	0	+0.08	18.83
1955	18.34	19.50	3.47	0	+2.31	16.03
1956	17.75	20.06	1.31	0	-1.00	18.75
1957	22.94	19.54	1.14	0	+4.54	18.40
1958	17.71	21.44	2.09	2.28	-3.92	19.35
1959	13.57	19.45	4.79	0	-1.09	14.66
1960	17.24	20.80	2.37	0	-1.19	18.43
1961	19.02	20.54	2.95	0	+1.43	17.59
1962	20.12	20.04	0.67	0	+0.75	19.37
1963	14.68	20.13	5.65	1.33	-1.13	14.48
1964	26.74	19.99	0	0	+6.75	19.99
Total	392.31	444.31	64.16	9.38	+5.78	377.15
Average	17.83	20.06	2.92	0.43	+0.26	17.14

Grande Prairie - Water Balance Summary - 10" Storage

Year	Precipitation	P. E.	Deficit	Surplus	Storage Change	E. T.
1943	14.16	20.35	3.34	0	-2.85	17.01
1944	17.61	22.09	5.61	0	+1.13	16.48
1945	13.25	19.73	6.63	0	+0.15	13.10
1946	11.98	20.41	9.87	0	+1.44	10.54
1947	19.03	20.12	0.34	0	-0.75	19.78
1948	22.29	20.25	0	0	+2.04	20.25
1949	15.63	20.18	3.66	0	-0.89	16.52
1950	16.51	19.21	3.01	0	+0.31	16.20
1951	20.75	18.21	0	0	+2.54	18.21
1952	15.50	20.76	0.51	1.33	-6.08	20.25
1953	18.58	19.68	2.31	0	+1.21	17.37
1954	18.91	18.83	0	0	+0.08	18.83
1955	18.34	19.50	3.47	0	+2.31	16.03
1956	17.75	20.06	1.31	0	-1.00	18.75
1957	22.94	19.54	1.14	0	+4.54	18.40
1958	17.71	21.44	0.09	0.28	-3.92	21.35
1959	13.57	19.45	4.79	0	-1.09	14.66
1960	17.24	20.80	2.37	0	-1.19	18.43
1961	19.02	20.54	2.95	0	+1.43	17.59
1962	20.12	20.04	0.67	0	+0.75	19.37
1963	14.68	20.13	4.32	0	-1.13	15.81
1964	26.74	19.99	0	0	+6.75	19.99
Total	392.31	441.31	56.39	1.61	+5.78	384.92
Average	17.83	20.06	2.56	0.07	+0.26	17.50

Grande Prairie - Water Balance Summary - 12" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E. T.
1943	14.16	20.35	3.34	0	-2.85	17.01
1944	17.61	22.09	5.61	0	+1.13	16.48
1945	13.25	19.73	6.63	0	+0.15	13.10
1946	11.98	20.41	9.87	0	+1.44	10.54
1947	19.03	20.12	0.34	0	-0.75	19.78
1948	22.29	20.25	0	0	+2.04	20.25
1949	15.63	20.18	3.66	0	-0.89	16.52
1950	16.51	19.21	3.01	0	+0.31	16.20
1951	20.75	18.21	0	0	+2.54	18.21
1952	15.50	20.76	0	0	-5.26	20.76
1953	18.58	19.68	1.49	0	+0.39	18.19
1954	18.91	18.83	0	0	+0.08	18.83
1955	18.34	19.50	3.47	0	+2.31	16.03
1956	17.75	20.06	1.31	0	-1.00	18.75
1957	22.94	19.54	1.14	0	+4.54	18.40
1958	17.71	21.44	0	0	-3.73	21.44
1959	13.57	19.45	4.60	0	-1,28	14.85
1960	17.24	20.80	2.37	0	-1.19	18.43
1961	19.02	20.54	2.95	0	+1.43	17.59
1962	20.12	20.04	0.67	0	+0.75	19.37
1963	14.68	20.13	4.32	0	-1.13	15.81
1964	26.74	19.99	0	0	+6.75	19.99
Total	392.31	441.31	54.78	0	+5.78	386.53
Average	17.83	20.06	2.49	0	+0.26	17.57

APPENDIX V

MOISTURE RETAINED IN THE SOIL AT THE END OF EACH MONTH IN THE GROWING SEASON

(1, 2, 4, 6, 8, 10, 12 inch Storage Values)

Soil Moisture Retained at the End of Each Month for the Growing Season
One inch Storage

Year	April	May	June	July	August	September	October
1943	0	0	0	0	0	0	0.7
1944	0	0	1.0	0	0	0.5	0
1945	1.0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0
1947	0.7	0	0	0	0	0	0
1948	1.0	0	0	0.3	0	0	0
1949	0.3	0	0	0	0	0	0.1
1950	1.0	0	0	0	0	0	0.1
1951	1.0	0	0	1.0	0	0	1.0
1952	0.4	0	0	0	0	0	0
1953	1.0	0.3	0.2	0	0	0	0
1954	1.0	0.2	0	0	0	0	0
1955	1.0	0.8	0	1.0	0	0	1.0
1956	0.7	0	0.7	0	0	0	0.5
1957	0.4	0	0	0	1.0	0	1.0
1958	0.1	0	0.2	0	0	0.6	1.0
1959	1.0	0	0	0	0	0	1.0
1960	0	0.5	1.0	0	0	0	0
1961	0.8	0	0.5	0	0	0.1	0.6
1962	1.0	0	0	0	0	0	0
1963	1.0	0	0	0	0	0	0
1964	0.7	0	1.0	1.0	1.0	0.8	0.1

Source: Dept. of Transport, Meteorological Branch Monthly Records 1943-64, and computed according to Thornthwaite's procedures as published in 1948.

Thornthwaite in this publication assumes that withdrawal of moisture from storage occurs at the optimum rate down to the wilting point. He has since modified this to allow for a decreasing rate of withdrawal as the wilting point is approached. (Thornthwaite and Mather op. cit., 1957).

Soil Moisture Retained at the End of Each Month for the Growing Season
Two inch Storage

Year	April	May	June	July	August	September	October
1943	0.4	0.4	0	0	0	0	0.7
1944	0.7	0	1.5	0	0	0.5	0
1945	2.0	0.6	0	0	0	0	0
1946	0.9	0	0	0	0	0	0
1947	1.7	0	0	0	0	0	0
1948	2.0	0	0	0.3	0	0	0
1949	1.3	0	0	0	0	0	0.1
1950	2.0	1.0	0	0	0	0	0.1
1951	2.0	0.9	0	1.4	0	0	2.0
1952	1.4	0	0	0	0	0	0
1953	2.0	1.3	1.2	0	0	0	0
1954	2.0	1.2	0	0	0	0	0
1955	2.0	1.8	0	1.3	0	0	1.0
1956	1.7	0	0.7	0	0	0	0.5
1957	2.0	1.3	0	0	1.0	0	2.0
1958	1.1	0	0.2	0	0	0.6	1.3
1959	2.0	0.5	0	0	0	0	1.4
1960	0.6	1.0	2.0	0	0	0	0
1961	1.8	0	0.6	0	0	0.1	0.6
1962	2.0	1.0	0	0	0	0	0
1963	2.0	0	0	0	0	0	0
1964	1.7	0.9	2.0	2.0	2.0	1.8	1.1

Soil Moisture Retained at the End of Each Month for the Growing Season
Four inch Storage

Year	April	May	June	July	August	September	October
1943	2.4	2.4	1.1	0	0	0	0.7
1944	2.0	0	1.5	0	0	0.5	0
1945	4.0	2.6	0.6	0	0	0	0
1946	2.9	1.1	0	0	0	0	0
1947	3.7	1.5	0	0	0	0	0
1948	4.0	1.7	0	0.3	0	0	0
1949	3.3	1.6	0	0	0	0	0.1
1950	4.0	3.0	0	0	0	0	0.1
1951	4.0	2.9	0.3	1.7	0	0	2.7
1952	3.4	1.1	0	0	0	0	0
1953	4.0	3.3	3.2	1.4	0	0	0
1954	4.0	3.2	1.3	0	0	0	0
1955	3.6	3.4	0	1.3	0	0	1.0
1956	3.7	0.4	1.0	0	0	0	0.5
1957	3.4	1.3	0	0	1.0	0	3.6
1958	3.1	0.3	0.5	0	0	0.6	1.3
1959	4.0	2.5	0	0	0	0	1.4
1960	2.6	3.0	4.0	0	0	0	0
1961	3.8	2.0	2.6	0.4	0	0.1	0.6
1962	4.0	3.0	0.6	0.1	0	0	0
1963	4.0	1.9	0	0	0	0	0
1964	3.7	2.9	4.0	4.0	4.0	3.8	3.1

Soil Moisture Retained at the End of Each Month for the Growing Season
Six inch Storage

Year	April	May	June	July	August	September	October
1943	4.4	4.4	3.1	0.3	0	0	0.7
1944	2.0	0	1.5	0	0	0.5	0
1945	6.0	4.6	2.6	0	0	0	0
1946	3.2	1.4	0	0	0	0	0
1947	5.7	3.5	0.6	0	0	0	0
1948	6.0	3.7	1.8	2.1	0.9	0.5	0
1949	4.5	2.8	0	0	0	0	0.1
1950	6.0	5.0	1.0	0	0	0	0.1
1951	6.0	4.9	2.3	3.7	1.8	0.2	2.9
1952	5.4	3.1	1.3	0	0	0	0
1953	5.7	5.0	4.9	3.1	0	0	0
1954	6.0	5.2	3.3	1.4	0.9	0	0
1955	3.6	3.4	0	1.3	0	0	1.0
1956	5.7	2.4	3.0	0.2	0	0	0.5
1957	5.1	3.0	1.3	0.3	1.3	0	3.6
1958	5.1	2.3	2.5	0	0	0.6	1.3
1959	6.0	4.5	1.5	0	0	0	1.4
1960	4.1	4.6	6.0	1.4	0	0	0
1961	4.0	2.2	2.7	0.6	0	0.1	0.6
1962	6.0	5.0	2.6	2.1	0.9	0	0
1963	6.0	3.9	0	0	0	0	0
1964	5.3	4.5	6.0	6.0	6.0	5.8	5.1

Soil Moisture Retained at the End of Each Month for the Growing Season
Eight inch Storage

Year	April	May	June	July	August	September	October
1943	4.5	4.6	3.3	0.4	0	0	0.7
1944	2.0	0	1.5	0	0	0.5	0
1945	6.2	4.8	2.8	0	0	0	0
1946	3.2	1.4	0	0	0	0	0
1947	7.7	5.5	2.6	1.8	0.3	0	0
1948	8.0	5.7	3.8	4.1	2.9	2.5	1.8
1949	6.3	4.6	1.8	0	0	0	0.1
1950	6.7	5.7	1.7	0.3	0	0	0.1
1951	7.3	6.2	3.6	5.1	3.1	1.6	4.2
1952	7.4	5.1	3.3	0.8	0	0	0
1953	5.7	5.0	4.9	3.1	0	0	0
1954	6.9	6.0	4.2	2.3	1.7	0.9	0.4
1955	4.0	3.8	0	1.3	0	0	1.0
1956	7.4	4.1	4.8	1.9	0	0	0.5
1957	5.1	3.0	1.3	0.3	1.3	0	3.6
1958	7.1	4.3	4.5	0	0	0.6	1.3
1959	7.3	5.8	2.8	0	0	0	1.4
1960	4.1	4.6	6.9	2.3	0.2	0	0
1961	4.0	2.2	2.7	0.6	0	0.1	0.6
1962	6.6	5.6	3.2	2.7	1.5	0	0
1963	8.0	5.9	2.0	0	0	0	0
1964	5.3	4.5	6.7	7.7	8.0	7.8	7.1

Soil Moisture Retained at the End of Each Month for the Growing Season
Ten inch Storage

Year	April	May	June	July	August	September	October
1943	4.5	4.6	3.3	0.4	0	0	0.7
1944	2.0	0	1.5	0	0	0.5	0
1945	6.2	4.8	2.8	0	0	0	0
1946	3.2	1.4	0	0	0	0	0
1947	8.9	6.7	3.8	3.0	1.5	0.4	0
1948	9.3	6.9	5.1	5.4	4.0	3.7	3.1
1949	7.6	5.9	3.1	0.1	0	0	0.1
1950	6.7	5.7	1.7	0.3	0	0	0.1
1951	7.3	6.2	3.6	5.1	3.1	1.6	4.2
1952	9.4	7.1	5.3	2.8	2.0	0.7	0
1953	5.7	5.0	4.9	3.1	0	0	0
1954	6.9	6.0	4.2	2.3	1.7	0.9	0.4
1955	4.0	3.8	0	1.3	0	0	1.0
1956	7.4	4.1	4.8	1.9	0	0	0.5
1957	5.1	3.0	1.3	0.3	1.3	0	3.6
1958	9.1	6.3	6.5	1.7	0	0.6	1.3
1959	7.3	5.8	2.8	0	0	0	1.4
1960	4.1	4.6	6.9	2.3	0.2	0	0
1961	4.0	2.2	2.7	0.6	0	0.1	0.6
1962	6.6	5.6	3.2	2.7	1.5	0	0
1963	9.3	7.2	3.3	0.1	0	0	0
1964	5.3	4.5	6.7	7.7	8.0	7.8	7.1

Soil Moisture Retained at the End of Each Month for the Growing Season
Twelve inch Storage

Year	April	May	June	July	August	September	October
1943	4.5	4.6	3.3	0.4	0	0	0.7
1944	2.0	0	1.5	0	0	0.5	0
1945	6.2	4.8	2.8	0	0	0	0
1946	3.2	1.4	0	0	0	0	0
1947	8.9	6.7	3.8	3.0	1.5	0.4	0
1948	9.3	6.9	5.1	5.4	4.1	3.7	3.1
1949	7.6	5.9	3.1	0.1	0	0	0.1
1950	6.7	5.7	1.7	0.3	0	0	0.1
1951	7.3	6.2	3.6	5.1	3.1	1.6	4.2
1952	10.7	8.4	6.7	4.1	3.4	2.0	0.8
1953	6.5	5.8	5.7	3.9	0.6	0	0
1954	6.9	6.0	4.2	2.3	1.7	0.9	0.4
1955	4.0	3.8	0	1.3	0	0	1.0
1956	7.4	4.1	4.8	1.9	0	0	0.5
1957	5.1	3.0	1.3	0.3	1.3	0	3.6
1958	9.3	6.6	6.8	2.0	0.2	0.8	1.5
1959	7.5	6.0	3.0	0	0	0	1.4
1960	4.1	4.6	6.9	2.3	0.2	0	0
1961	4.0	2.2	2.7	0.6	0	0.1	0.6
1962	6.6	5.6	3.2	2.7	1.5	0	0
1963	9.3	7.2	3.3	0.1	0	0	0
1964	5.3	4.5	6.7	7.7	8.0	7.8	7.1

APPENDIX VI

Beaverlodge Potential Evapotranspiration for Months with Mean Temperature Below 32°F

Based on Data Compiled from Daily Records
(1943-1956)

Year	January	February	March	April	---	October	November	December	Total
1943	0.18"	0.37"	0.12"				0.51"	0.28"	1.46"
1944	0.16	0.07	0.51				0.16	0.13	1.03
1945	0.14	0.11	0.55	0.66			0.05	0	1.51
1946	0.03	0.07	0.51				0.32	0.05	0.98
1947	0.18	0.09	0.53				0.20	0.05	1.05
1948	0.14	0.06	0.13	0.37			0.25	0	0.95
1949	0.09	0.08	0.40				0.70	0	1.27
1950	0	0.03	0.24	0.68			0.14	0.07	1.16
1951	0.02	0.09	0.25			0.92	0.17	0.05	1.50
1952	0.04	0.10	0.29				0.42	0.10	0.95
1953	0.03	0.19	0.35	0.77			0.19	0.13	1.66
1954	0.04	0.29	0.14	0.35			0.51	0.19	1.52
1955	0.06	0.10	0.32				0.11	0.01	0.60
1956	0	0.09	0.27				0.61	0.23	1.20
Mean	0.08	0.12	0.33				0.31	0.09	1.20

Source: Soil Moisture Budget--Daily Tabulation 1921-56.
Station - Beaverlodge, Alberta.
Prairie Provinces Water Board "Study of the Aridity of the Prairies."

An average of more than one inch of water is lost through potential evapotranspiration (nearly all in the form of evaporation) during the winter period. Grande Prairie is only 26 miles from Beaverlodge so the amount lost there will be almost identical. None of this loss appears in the calculations done using mean monthly temperatures. Average surpluses, therefore, for Grande Prairie are, in reality, less than have been plotted and the

deficits are greater by 1.2 inches.

However in the transfer of the Grande Prairie data to an area of slightly higher precipitation it can mean that this loss is to some extent compensated by the increased precipitation. The actual evapotranspiration, deficits, and surpluses plotted on Figures 15, 16, and 17 are those which are really valid for an area with 1.2 inches more precipitation. The average amount of precipitation over the Spring Creek basin area in the last twenty two years was probably about 19 or 20 inches compared with 17.8 at Grande Prairie. It is felt therefore that there is some justification for stating that in this case the accuracy of the water balance patterns have not decreased in the transfer--in fact the opposite is more likely.

The degree of accuracy of the surpluses and deficits still depends on the local applicability of the procedures used and to some degree on the accuracy of the meteorological measurements made. In the case of snowfall the actual measurement can vary greatly from the true amount depending on such factors as wind velocity and the density of the snow as it falls. No allowance can be made for these variables but they operate at all stations.

APPENDIX VII

CEREAL CROP YIELDS

For Census Division 15 (1943-56) and for Division 15 (1956-64)*

Year	Yield in Bushels per Acre		
	Wheat	Oats	Barley
1943	21.2	38.2	26.8
1944	24.8	41.8	30.0
1945	21.2	32.0	21.8
1946	18.2	35.4	23.5
1947	22.6	45.6	31.3
1948	14.3	23.9	20.1
1949	24.8	46.3	29.6
1950	10.6	25.1	16.0
1951	21.3	45.0	34.7
1952	28.1	53.1	35.4
1953	29.2	54.3	36.6
1954	25.8	44.4	31.9
1955	21.5	40.1	25.9
1956	23.9	44.7	29.2
1956	23.5	46.0	30.4
1957	10.9	39.8	26.8
1958	14.0	25.0	16.4
1959	20.3	34.0	26.6
1960	22.3	37.0	27.2
1961	26.6	45.7	34.1
1962	25.1	48.0	32.8
1963	10.4	26.4	15.1
1964	22.8	46.4	30.5

*Census boundaries were altered for the 1956 census.

Source: 1) Acreage, Yields, and Production of Wheat, Oats, and Barley by Census Divisions. 1921-1956, inclusive. Govt. of Alberta, Dept. of Agriculture, Agricultural Extension Service.

2) Yields by Census Divisions (1956-64). Farm Economics Branch, Alberta Department of Agriculture.

APPENDIX VIII

DISTRICT AGRICULTURISTS' QUESTIONNAIRE

Suite 7,
6815 - 112 Street,
Edmonton, Alberta.
July 5th, 1965.

Dear Sir:

I am a graduate student in the Department of Geography at the University of Alberta and am working on an M. Sc. thesis concerned with the water and land resources of the Spring Creek basin (the area around Tp. 68, R. 25, W. of the 5th Meridian) as a guide to agricultural potential, and also dealing with problems arising from erosion, sedimentation, flooding, summer and autumn water deficits and so on.

This basin is approximately 10 to 15 miles south of Sturgeon Heights and is also being studied by the Water Resources Division of the Department of Agriculture who are employing me this summer and paying me to do my thesis research. Water Resources is studying this basin as a project under the International Hydrologic Decade and they hope to gauge all tributaries, place about twenty precipitation gauges in the 42 square miles' area, have some temperature recording stations, and also check on soil moisture detention and retention rates, and the variations in groundwater levels.

This will be done every year until the area is opened up for settlement and then continued afterwards to see what changes can be determined as having been caused by cultivation, especially changes in runoff patterns.

For my part, I hope to map the soils and surficial deposits in detail, to measure slopes, and to try to evaluate which areas are likely to suffer erosion under various types of cultivation. I hope to recommend

areas suitable say for grains, for mixed farming, for permanent pasture, and areas which should be left under forest.

All these records should be of some assistance in the future when new land is being opened up in the Peace River block.

I have spent some time in visiting similar soil types in other parts of the Peace River area which are already farmed to give me some idea of what to expect from the Spring Creek area in about ten years' time. I would be very grateful if you could give me the benefit of your experience and help me with some general questions. I appreciate the fact that you may not look at the farms in the same light as I do but you have visited many more, are more acquainted with their problems, and have been in the Peace River area for longer than I have.

(1) What would be the least size of farm you would consider to be a worthwhile proposition under the following type of soil?-an area of Culp soils with a fair amount of marshy hollows among the sand and in general composed of low rolling hills say rising 20 feet or so above the hollows.

(2) Do you think wind erosion would be a serious problem on these soils in this part of the country?

(3) What sort of agricultural land use (including some information on a suitable crop rotation) would you recommend on a sandy area of this type with rolling topography?

(4) Would you say that it is worth developing an extremely sandy soil (almost undifferentiated sand in the Soil Survey reports) for mixed farming of any type, or would it be better under permanent grass, or should it be left untouched?

(5) Would you consider a Braeburn soil on say a hillside location, (up to 5 percent slope) with a fair amount of stones, to be a better farming soil than Culp?

(6) Have you seen any (or many) examples of soil erosion on this type of soil? (Braeburn).

(7) What sort of land use (including some information on a suitable crop rotation) would you recommend in this type of area?

(8) What would be the least size of farm you would consider to be a worthwhile proposition under this type of soil?

(9) How would you rate a rather gravelly Codesa with slopes of up to 5 percent, and a clayey subsoil about 3 to 4 feet down, when compared with the two previous types?

(10) Have you seen any (or many) examples of soil erosion (water or wind) on Codesa soils in general? (You may not have had to deal very much with the specific phase mentioned in question 9.)

(11) What sort of agricultural land (including some information on suitable crop rotations) would you recommend for this type of area?

(12) What size of farm would you say would be necessary to make farming on this type of soil an economic proposition?

(13) Can you give me any information on rather shallow Kenzie or Eaglesham soils which have been developed for agriculture?

(14) Would you consider any work being done on deep soils of these two types or should they be left to act as 'water reservoirs' to even out streamflow regimes?

(15) How would you rate a fairly flat Donnelly area (with a little Codesa) when compared with the previous soil types?

(16) What sort of agricultural land use (including some information on suitable crop rotations) would you recommend for this type of area?

(17) Have you seen any examples of water or wind erosion on this type of soil?

(18) What size of unit would you say is the minimum necessary to make a farm on this type of soil a worthwhile proposition?

(19) When an area is cleared of bush for farming purposes would you recommend grain first, or a few years of clover to build up more organic matter? This may vary with slopes or soil types or amount of weeds present but give any information you consider to be useful.

(20) What varieties of wheat, barley, oats, rapeseed, legume or grass cover would you recommend for the following situations? (Some may not apply, some of the information given may not be clear enough to give you a good idea of what I mean, but do as well as you can with the information.)

(a) A rather gravelly Braeburn with say 2-5 percent slopes, on the whole sloping down to the south.

(b) A rather sandy Culp on rolling ground, near a dissected valley edge and open to strong winds.

(c) A rather gravelly Codesa with the same degree of slope as above but with no particular orientation with regards to sun.

(d) A flat Donnelly area with some Codesa in patches.

(e) Eaglesham or Kenzie type soils.

(f) A drained hollow with Goose or Codner soils.

(21) If you could add any information along the lines of the previous soils concerning Codner or Goose this would be most helpful.

(22) Do you approve of the practice of having summer fallow in crop rotations? Try to give reasons.

Please answer as fully and as specifically as you can, and just whenever you can find the time, if you have it. I have to give a preliminary report say by mid-August and would be grateful if you could give me as much information as you can manage, if possible, before the end of the first week in August.

I will probably be sending this to a few District Agriculturists in the area in an attempt to get a few points of view. The answers can be no more than a person's own point of view but I would like to have access to experience gained by others to supplement my own observations.

Yours sincerely,

Ian MacIver.

GOVERNMENT OF THE PROVINCE OF ALBERTA
Department of Municipal Affairs

Spirit River, Alberta,
July 27th, 1965.

Mr. Ian MacIver,
Suite #7,
6815 - 112th Street,
Edmonton, Alberta.

Dear Sir:

We have your letter to Mr. Graves at hand. He is away from the office at present and since he is quite busy, he has asked me to answer those questions which I feel qualified to answer. He hopes that you will get sufficient replies from other District Agriculturists in the area to cover the other questions.

The numbers below correspond to the numbers of your questions:-

1. At least one section of land would be required for a mixed farming operation on such land.
2. Wind erosion would probably be confined to the hilltops and should not be serious.
3. No. Some of the better areas might support a permanent pasture or hayfield.
6. Yes, -we have a number of examples of serious gully erosion on Braeburn soils in the Central Peace Area.
8. Three quarters of a section would be a minimum size.
15. Donnelly soils have given fairly good returns in the district. They

would rate much better than the types mentioned partly because of level topography.

17. Water erosion could become a problem. Wind erosion is unlikely as the soil is usually lumpy.

We hope that these comments will be of help to you.

Yours very truly,

"H. W. Glidden"

H. W. Glidden,

Assessor & Inspector

HWG:jgi

PROVINCE OF ALBERTA

DEPARTMENT OF AGRICULTURE

AGRICULTURAL EXTENSION SERVICE

Spirit River, Alberta,
August 25th, 1965.

Mr. Ian MacIver,

Suite #7,

6815 - 112th Street,

Edmonton, Alberta.

Dear Mr. MacIver:-

Further to your letter to this office of July 27th, we have attempted to answer your questions below, and the numbers correspond to the numbers in your original letter of July 5th.

1) We would agree with Mr. Glidden, i. e. at least one section - major enterprise livestock (cattle) to allow growth and disposal of forage crop.

2) Not really - water erosion would be a far more serious problem - under heavy summer storms.

3) Growing of forage crops - grasses and legumes for seed production, hay or pasture. Use of fertilizer to maintain stand.

4) Certainly such soil would be best under permanent pasture if broken at all. Native growth should give some clue as to whether the soil would.

5) The Braeburn soil would probably be a better farming soil than Culp if erosion (by water) could be avoided - see question 7.

6) Yes - see Glidden's statement.

7) A rotation involving forage crops predominantly would be called for under the circumstances described.

8) Four quarters would probably be the smallest size of farm which would return a reasonable level of income.

9) The Codesa soil would be rated somewhat better.

10) Erosion would probably not be too great a problem.

11) Forage crops, including deep rooted legumes.

12) Four quarters

13) Hay production only.

14) Probably should be left as water reservoirs.

15) Donnelly probably rated higher than previously mentioned soils. Main problem is surface crusting and impeded subsoil drainage.

16) Forage crop (including legumes, e.g. sweet clover) production with grain.

17) Not extensive--perhaps black summerfallow should be avoided. Water erosion takes place during fallow year.

18) Four quarters. (This question of farm size is difficult to answer.) When we think of size we think in terms of number of acres. But there are of course other ways of measuring size. When we say 4 quarters of land is needed for an adequate size of farm we are assuming the type of farm operation presently carried out. Obviously a "large" hog or poultry farm could for example be established on a quarter section of land (or less). So when we talk of size, we should also indicate the type of farm enterprise.

19) This question involves not only soil types, weeds, etc. but probably more importantly, economics - "money". Most people involved in land

clearing are interested in obtaining some fairly quick returns. It is very well to say - clear land and seed to clover to build up organic matter - but who among us can wait 3 or 4 years for returns to start coming. On the other hand, we cannot afford to grow grain and so allow soil to lose what bit of organic matter it may have. It seems that a middle way is called for - perhaps take off a first grain crop (let's hope it's good so that there is some "net income") then seed down to forage crop.

20) a) Legume and grass crops only recommended - alsike or Red Clover, Alfalfa, sweet clover. Try grasses as fescue, brome.

b) Legumes - alsike, red clover, sweet clover; grasses - pubescent wheat grass, timothy.

c) Legume - sweet clover; grass - try crested wheat grass (for seed) grass-legume mixture for pasture.

d) Legumes - alsike clover, red clover; grasses - try fescue, brome, timothy.

e) Native grass - or red canary grass.

f) Red canary or brome grass.

(For pasture and hay production, a mixture of grasses and legumes would be called for. Single species would be grown only if for seed production.)

21)

22) No doubt some summerfallow at least partial fallow, is called for. By partial fallow, we mean fallowing after a hay or grass crop is harvested say by mid-July. Then field is fallowed for remainder of the year - this allows sod and stubble to be incorporated. There probably is little need for complete fallow - especially on the types of soils being discussed here.

We trust this information will be of some help to you.

Yours very truly,
"s" F. Graves
"t" F. Graves,
District Agriculturist.

FG:jgi

PROVINCE OF ALBERTA

DEPARTMENT OF AGRICULTURE

AGRICULTURAL EXTENSION SERVICE

Provincial Building
Grande Prairie, Alberta

July 29, 1965

Mr. Ian MacIver,

Suite 7,

6815 - 112 Street,

Edmonton, Alberta

Dear Mr. MacIver:

In regard to your Master's Thesis concerning the Water and Land Resources of the Spring Creek Basin Township 68, Range 25, West of the 5th Meridian, let me first of all say that you have a most difficult area on which to assess the agricultural potential.

From your studies already you will know that the soil has been rated by the Soil Survey of the Research Council as generally #5 soil. This is itself should be enough to discourage most people from utilizing it as homestead land in the foreseeable future.

The area is in a medium high rainfall area, probably in close to the 20" range. Muskegs are quite common throughout the whole of the Township and are especially predominant in the South East corner. Much of it is overlain by a heavy sub-soil so drainage is going to be a problem.

The growing season, due to moisture distribution and to lack of clearing and possible elevation, is probably shorter than in the farming areas around Valleyview or Crooked Creek. As a result of this

we would feel that the area, if open for settlement, would only be suitable for the production of feed grains to a limited extent, with the production of cattle predominating. This, therefore, would mean fairly large acreage necessary for each individual farmer, and consequently, very few farms in the Township.

We will now try to answer your questions as you have them listed in your letter.

1. The least size farm which we would consider to be worthwhile would be a farm running a very minimum of 50 brood cows. This would require probably 3/4 to a section of land directly at home plus some grazing land to carry them through the middle of summer.

2. We would consider that wind erosion would not be too great a problem in this area because of the necessity of leaving fair amounts in natural cover due to the predominance of muskeg and other low-lying areas.

3. A suitable crop rotation for this sandy area might be approximately three years in a grass and legume mixture utilized by both hay and pasture, followed by working down planting crop of equal barley and oats and the following year seeding back down to grass and legume, probably with a barley nurse crop.

4. The most extreme sandy soil would probably be best left more or less untouched. Cultivated grass species would be scattered through this area and would likely soon take over from the less palatable native grasses.

5. In this area where grass and legume are going to be a predominant part of the rotation, we would consider that probably the Culp soil would be nearly equal to the Braeburn soil.

6. Water erosion can most certainly be a very serious problem in these soils but should not be if a good rotation is followed.

7. We would recommend the same land use here as in question 3.

8. The size of farm in this area would likely be nearly as great since we think you will find quite a large number of low muskeg areas in here as well. Farming most of this area is going to be very difficult for quite a while in the spring.

9. A rather gravelly Codesa soil would not likely rate as highly as the two soils previously discussed.

10. Yes, we have seen considerable erosion on this type of soil.

11. Same land use as previously mentioned.

12. Same size as previously mentioned.

13. Kenzie and Eaglesham soil generally take too long to bring into reasonable production to be considered as economical, especially for grain crops. Some of the grass may do favorably in these soils once they become established.

14. We would consider the best use as water reservoirs, in fact we would consider this whole area's main use as a water reservoir.

15. The Donnelly soils are not exceptionally productive, but would probably compare quite similarly to the use to which they should be put in this area. They are much more difficult to work and can probably not take as much pasturing as your previous soils.

16. The production of forages should be the main consideration on the Donnelly soils in this area.

17. The Donnelly soils, if on a slight slope, are very subject to water erosion.

18. The size of farm mentioned previously would probably apply to this soil.

19. When this land is cleared of bush, much of it should be put into clover and grass immediately. It is not likely that you would find many weeds present in that area. On cleared land fireweed and regrowth of poplars would be the main weed growth.

20. The varieties of grains to recommend for this area is quite a problem. We would hesitate to recommend wheat of any variety due to the shortness of the season. Your temperature records may prove me wrong on the length of growing season, so these are merely assumptions. The variety of wheat which would come closest to fitting the season would be Garnet. Of the barleys, only Olli and probably Gateway 63. Of the oats varieties, Glen may be the best variety. The Echo rape may be suited to the area. Of the grasses and legumes any of the regular varieties of Creeping Red Fescue, Brome grass, Timothy, Alfalfa, Alsike and Altaswede would be suitable.

21. No further information.

The use of summer fallow in this area would be unnecessary and not recommended. The only period of summer fallow would be during the time that the clover and grassland was being broken up in preparation for the seeding of the grain crop.

From our previous comments you may have guessed that we are not overly enthusiastic about the prospects for development of this area into a grain growing farming operation.

If you have not done so up to the present time, we would suggest that you talk to Mr. William Odynsky of the Alberta Research Council of Soil Surveys and Mr. Don Sawyer of the Lands and Forests Department. Both of these gentlemen reside in Edmonton. Another man who is worth contacting in regard to this is Mr. Art Paul, now retired from the Lands Branch and residing, we believe, in Edmonton.

We are enclosing for your information the Research Highlights for 1964 from the Federal Research Station at Beaverlodge. If we can be of further assistance to you, please let us know.

The best of luck to you in your study of this area.

Yours truly,

Neil G. Miller, P. Ag.,
District Agriculturist
per "H. J. Spiden"

NGM:hjs

Enclosure

APPENDIX IX

FARMERS' QUESTIONNAIRE

QUESTIONNAIRE

1. Name (Surname) Turcotte Given name(s) J. J.

Land Description

Qr.	Sect.	Tp.	Range	Merid.
N 1/2	19	75	19	W5
SE 1/4	30	75	19	W5
SW 1/4	13	75	20	W5
NE 1/4	15	75	20	W5

2. Total size of farm is 800 acres.

Number of acres being cultivated is 740.

3. This land has been farmed for approximately 17 years. Try to give a rough estimate dating from the first breaking done for cultivation.

4. Was the land put under pasture or hay after being cleared, or was it put under grain as soon as possible?

Pasture or hay____

Grain X Tick whichever applies.

5. Has there been any decrease in crop yields after a number of years of cultivation? Yes_____ No X Note that allowance should be made for variations in rainfall since the question refers to natural fertility.

6. Would you say that the land is in better shape now than it was, for example, ten years ago? Yes X No_____

7. Do you use any type of fertiliser? Yes____ No See other side of page

If the answer is yes, which types do you use?_____

_____

8. If fertilisers are used, do you use more than previously to keep yields up to the same level? Yes_____ No_____

9. When the land was cleared for cultivation were any windbreaks left?

Yes_____No___X___

10. a) Have you ever noticed any signs of wind erosion on your property?

Yes____X___No_____

b) If the answer is yes, during which time of year did the erosion take place? 1. Spring_____2. Summer__X_____3. Fall__When the flax was 2" high_____

c) How serious was the erosion?

1. Very little_____ 2. Moderate___X___ 3. Heavy_____

Add any other information you think may be useful. I would recommend leaving wind breaks not forgetting around the buildings ---

11. Have you ever noticed any signs of water erosion on your property?

Yes____X____No_____This may occur, for example during spring meltwater runoff or possibly in a month of exceptionally heavy rainfall especially on sloping ground. If the answer is yes, give some details regarding time of year, part of farm (i.e. upper slopes, bottom land, etc.), extent and depth of deepest gullies. As our land has a gradual slope of about 40 feet in a half mile, we have quite a problem with erosion in the spring. To combat this we have ditches around all our land.

12. Have you had any trouble with ditches silting up? Yes X in spots

No_____

13. Have you had any trouble with finer soil being washed off slopes and deposited at the bottom? Yes_____No_____

14. a) If there is any erosion due to wind and/or water, have any steps

been taken to reduce it? Yes X No

b) If the answer is yes, what steps were taken to reduce it?

1. Contour farming
2. Strip farming
3. Windbreaks
4. Pasture
5. Hay
6. Stubble mulches X
7. Other ditches
8. Other (Describe)

15. Have any lowlying marshy areas been drained for farming? Yes
No

16. If this is the case, are they more fertile than the rest of your land?
Yes No

17. Do they suffer from flooding, for example under conditions such as have existed this summer or last summer? Yes No

18. Have you had to drain (or cultivate without drainage) some minor marshy hollows in order to obtain fields of sufficient size, or to improve field cultivation efficiency? Yes, size 1 acre
Yes, efficiency poor No

19. Would the crops in these minor hollows suffer due to waterlogged or alkaline conditions? Yes, waterlogged X Yes, alkaline No

20. Taking one particular field on your farm, describe the crop rotation that you would use. Clover 1 year wheat or barley for 2 years summer fallow then grain and clover

21. What grains, forage and other crops do you grow?

Crop	Variety	Acres
Wheat		285
Barley	Olli	55

Crop	Variety	Acres
Oats		
rape	Arlo	50
summerfallow		215
clover	alsike	130

22. Have you been satisfied with the yields you have obtained from these crops? One year in ten 50 bus. wheat Four years in ten 40
Six years in ten 35 Nine years in ten 25

23. Do you keep livestock and poultry? No

24. Try to estimate what proportion of your farm revenue is obtained from the sale of the following products.

Grains 75 % Fodder crops ____ % Clover Other 15 %
Livestock ____ % Rape Seed 10% % ____
Livestock Products (milk, eggs, etc.) ____ %

25. What proportion, if any, of your total income is obtained from a job which has no connection with your farm? ____

. Is it necessary to have another job to make ends meet on your size of farm and type of soil -- a) in the initial homesteading period Yes X No
b) once clearing is complete Yes ____ No X

26. Taking your own farm and type of soil as examples, what size of holding would you consider to be necessary to make farming a paying proposition? From four to six quarter sections or even more -----

27. Have crop yields ever suffered in any year because of lack of water in the spring, summer or autumn?

Spring ____ ____ years out of ten
Summer X 6 years out of ten
Autumn ____ ____ years out of ten

28. Have crop yields or crop harvesting ever been affected in any year by late spring or early fall frosts?

Late spring_____ _____years out of ten

Early fall____X_____ _____5_____years out of ten

29. What is the average date about which you would normally start work on the land in the spring?__The first week in May_____

In answer to questions 5, 6 and 7 I wish to explain that the first 3 or 4 years we sowed grain on the breaking with not too good a result. So we started to seed alfalfa and clovers (alsike mostly) for seed and when the legume crops were ploughed back we almost doubled our yields so from then on we sowed our breaking to a legume crop along with a nurse crop of wheat or flax. About six years ago we tried fertiliser 11/48 and 16/20 for 3 years running but couldn't see the difference in test strips we left unfertilised. For the past 3 years again we used no fertiliser while our neighbours are still using it and we still thresh more bushels per acre than they do. For instance this year we had a yield of 70 bushels per acre of Olli barley on a field of alfalfa that is harvested now. The wheat which is still standing on alsike and alfalfa land I expect will yield over 40 bushels per acre while another field of summer-fallowed land that has had legume crops about 4 and 5 years back is expected to yield about 35 bushels per acre.

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